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DEVELOPMENT AND EVALUATION OF
CATALYSTS FOR HYDROGENATION OF
CONDENSED POLYNUCLEAR
AROMATIC COMPOUNDS

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by

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ABSTRACT

The hydrogenation of naphthalene, phenanthrene, chrysene and perylene was studied over sulfided Ni-W and sulfided Co-Mo catalysts over a range of conditions. The reaction was studied by a Flash Hydropyrolysis (FHP) technique. Both the catalysts were found equally active and yielded gaseous and hydrogenation products in significant amounts. In the majority of experiments, the ratio of catalyst/sample varied from five to ten. The effect of the catalyst to feed ratio and concentration of hydrogen on yield was also studied. A gas chromatograph was used to provide quantitative analysis of the liquid and gaseous products. The liquid products condensable at -78°C were analyzed by capillary gas chromatography-mass spectrometry. Hydrogenolysis reactions took place over these catalysts successively. The cracking of the terminal ring was extensive, though evidence has been found for the reaction path involving saturation and cracking of the central ring.

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I INTRODUCTION

The conversion of high molecular weight materials to lighter products is becoming increasingly important as a result of decreasing availability of lighter feedstocks. The materials include residues from refineries, tar sands, oil shales, coal, biomass and others. The conversion of these feedstocks offers an alternative potential for energy process development to offset the increasing imports of large amounts of crude petroleum in the near and intermediate future.

The process of conversion must be efficient and economically viable. Most of the above feedstocks contain high molecular weight (low volatility) compounds, hetroatoms and high aromaticity not found to the same degree in lighter feedstocks. All these characteristics require severe conditions for their conversion to synthetic fuels resulting in higher process costs and lower degree of conversion to the desirable products. Currently there are several key synthetic fuel processes in the stage of R and D and pilot plant applications, such as gasification of coal, Liquefaction of Coal, Coal-Methanol-Gasoline and Ethanol from Bio-mass. Most of them have been studied and developed for many years. The development and application of new technologies is necessary to overcome the conversion difficulties, to decrease production, recovery and processing cost

and to reduce and control the impacts of energy production on the environment and public health.

One of the promising techniques for converting hydrocarbon feedstocks such as coal, oil sands and biomass into useful synthetic fuel liquids and gases is the Flash Hydropyrolysis technique (FHP). As a coal liquefaction process, Flash Hydropyrolysis (FHP) is a rapid gas-phase hydrogenation technique that involves both hydroliquefaction and pyrolysis. In addition to high liquid yields, this technique also produces gaseous products. In recent years FHP process has attracted considerable attention because it offers a simple method of converting carbonaceous feedstock to commercially valuable products such as synthetic natural gas (SNG), fuel oil and BTX liquids (1,2).

The FHP processes are based on reaction of feedstock with hydrogen at high temperature and pressure, high mixing rate and short residence time. The thermal treatment causes opening up of the polynuclear aromatic (PNA) hydrocarbon ring structure of the molecule and formation of free radicals. The hydrogen is believed to participate as a diluent and as a participant in free radical chain propagation, e.g. $R\cdot + H_2 \rightleftharpoons RH + H\cdot$ forming low molecular weight species and inhibiting second order polymerization or condensation reaction. By using short residence time and rapid quenching, the reaction is

terminated preventing dehydrogenation, repolymerizations, carbonization and decomposition.

Although the available literature on the fundamental information on FHP process is presently sparse, it has been recognized that the reactions occurring during FHP processes are complex. The products yields, composition and distribution is dependent on process variables such as pressure, temperature, rate of heating and residence time.

Several laboratories in the United States and Canada are presently engaged in Coal Liquefaction research studies using Flash Hydropyrolysis Technique. Processes currently under development are at Brookhaven National Laboratories (BNL), the Cities Service, Rockwell International, and Occidental Research Corporation. All these organizations are in the United States of America. The work at BNL has shown (3) that a high conversion ~89% of lignite coal to liquids, and gaseous products is achieved using the following conditions: temperature, 700-800°C: Pressure, 1500-2000 psig: residence time, 10-20 seconds. The conversion of lignite coal comprise 26% liquids (16% C5 + BTX and 10% heavy oils), 48% gaseous hydrocarbons (C5) and 15% CO + CO₂. The 10% heavy oil found in the product is mainly composed of PNA type compounds. A total

of 32 PNA's were identified and quantified (see Appendix I, Table 1). The advancement of the modern analytical technique (GC, MS, GC-MS) now enables a quick identification and quantification of the diverse spectrum of FHP products. This increase in experimental capabilities allows the understanding and development of new cracking techniques.

Flash Hydropyrolysis in the presence of catalysts may offer significant improvements in conversion efficiency of PNA's to liquid products at relatively less severe reaction conditions than non-catalytic FHP studies. The use of catalysts has not been studied in FHP process in detail in the past. An effective catalyst would crack the PNA structure and maximize product yields. It would also allow the use of milder conditions and lower hydrogen consumption. The fluidity of hydrocarbons produced in the FHP process can be increased by saturation of bonds with hydrogen. The fuel product market value is dependent on the H/C ratio. In general, market value moves upward as the fuel product becomes lighter and the H/C ratio increases.

Our studies on catalytic Flash Hydropyrolysis of PNA's began with an object of the development of catalysts to convert PNA molecule, relatively deficient in hydrogen to a more liquid form. The selected catalyst

is therefore expected to accomplish adding hydrogen to the PNA molecule, eliminating carbon, or a combination of the two. Ideally, such a catalyst should be evaluated economically. If it appears feasible, systematic studies should be undertaken.

In the petroleum industry Ni-W and Co-Mo have been used extensively for the production of synthetic fuels from coal, oil shale and tar sands. These catalysts were also used in the present investigation. The catalyst was presulfided in the reactor so that the active form of the catalyst contains Ni-W, Co-Mo as the sulfide.

Naphthalene, phenanthrene, chrysene and perylene are typical of PNA's produced during the liquefaction of coal, with the staggered phenanthrene-like compounds being thermodynamically more stable than linear anthracene-like isomers (4). Phenanthrene derivatives are usually present in greater abundance in coal derived liquids (5). These pure model compounds were Flash Hydropyrolyzed over the sulfided Ni-W and Co-Mo catalysts in a FHP reactor. GC and GC-MS techniques were used to identify and quantify the products. The data has been carefully examined for conversion and material balance on carbon obtained. In this report, the data on FHP of phenanthrene, naphthalene, chrysene and perylene is presented and recommendation for future work is indicated.

II EQUILIBRIUM CONSIDERATIONS

Some information on the equilibria of hydrogenation will provide an insight in the interpretation of the data obtained in this study. The thermochemical data on anthracene, naphthalene and phenanthrene has been reported in earlier studies by Stull et al (6). Frye has studied thermodynamic equilibria in the hydrogenation of a number of aromatic compounds (7,8).

The equilibria plots for hydrogenation of phenanthrene is given in Figure 1. The equilibrium concentration as a function of temperature and pressure is given in Figure 2, 3 and 4. It can be seen in figure 2 that from a thermodynamic point of view, phenanthrene can be hydrocracked to form toluene in high yields at about 800°F. At higher temperatures the equilibrium becomes increasingly less favourable.

Large conversions are possible at elevated pressures and at high hydrogen to phenanthrene ratios. At 1300°F and at a hydrogen to phenanthrene ratio of 10:1 it is estimated that 80% of phenanthrene can be converted to toluene at 2000 psi. At a higher temperature other reactions such as conversion of toluene to thermally hydrodealkylation reactions are taking place as given in figure 3: $C_{14}H_{10} + 5H_2 \rightleftharpoons 2C_6H_6 + 2CH_4$. This reaction

is thermodynamically favourable at temperatures approaching 1400 F, and high conversions may be expected at this temperature even at atmospheric pressure.

The conversion reactions of condensed PNA's will certainly involve hydrogenation (9). Therefore, consideration of hydrogenation reactions are very useful. The hydrogenation reactions are exothermic and are thermodynamically favoured at low temperatures. At severe conditions, it is thus anticipated that the concentration of the hydrogenated species will be quite low. Equilibrium plots of some hydrogenation products are presented in figure 4.

In equilibrium calculations, it has been tacitly assumed that the reaction mixture is an ideal gas. Under non-equilibrium conditions and at low temperatures, the extent of conversion will be limited by reaction kinetics, so that the final hydrogenation products will also depend upon the particular catalyst used. It is also possible that hydrogenated species formed serve as reaction intermediates.

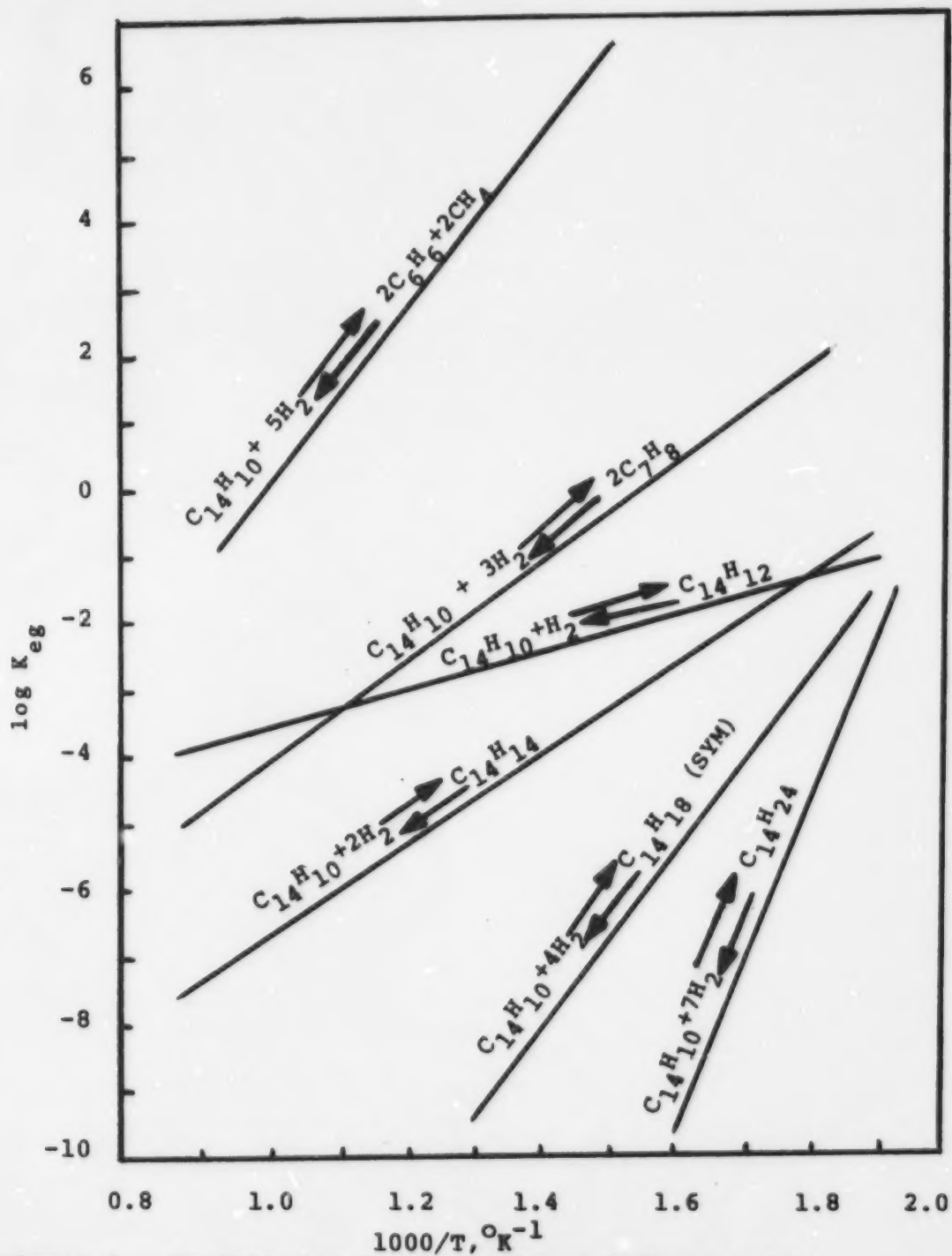


Figure 1. Equilibrium in phenanthrene hydrogenation reactions.

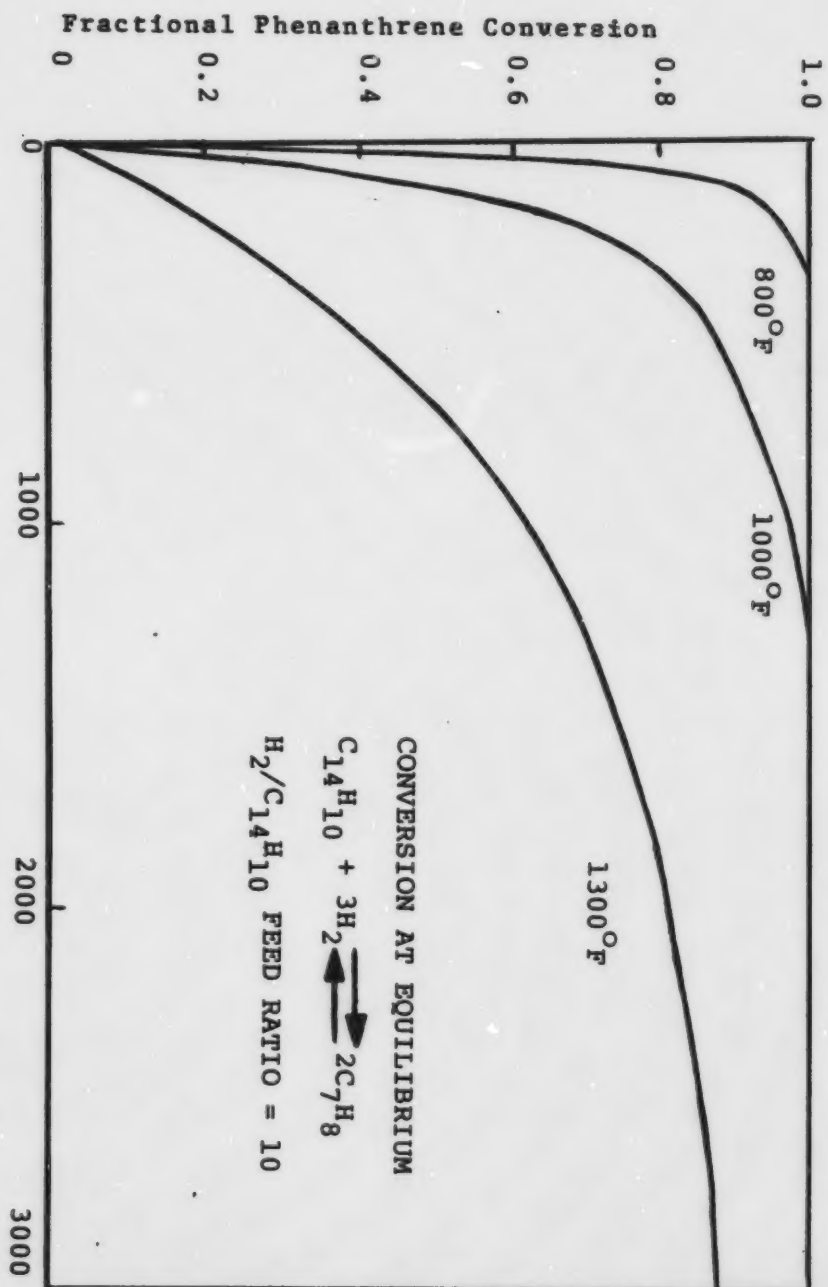


Figure 2. Equilibrium in the system $C_{14}H_{10}$, C_7H_8 .

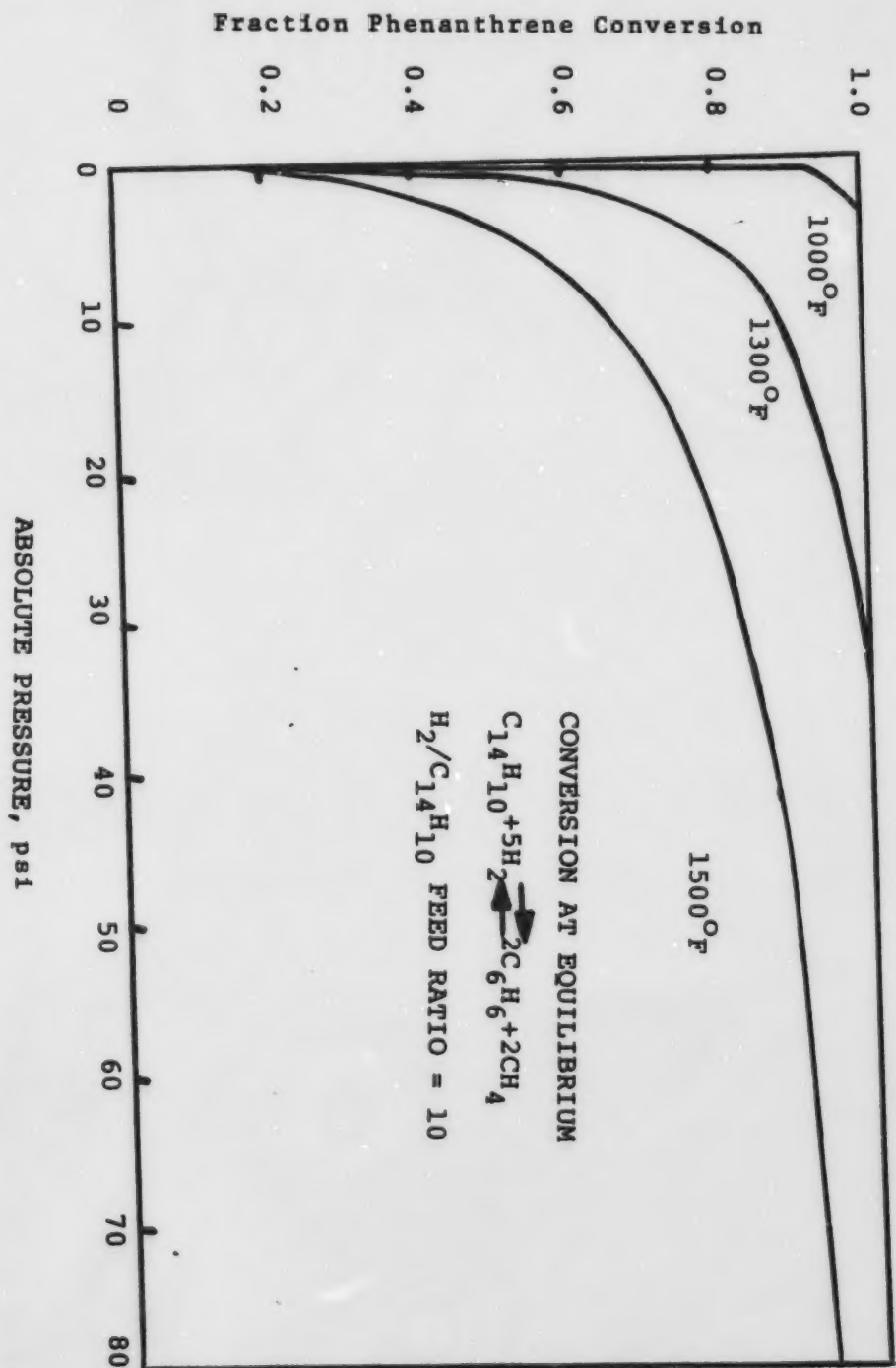


Figure 3. Equilibrium in the system $\text{C}_{14}\text{H}_{10}$, H_2 , C_6H_6 , CH_4 .

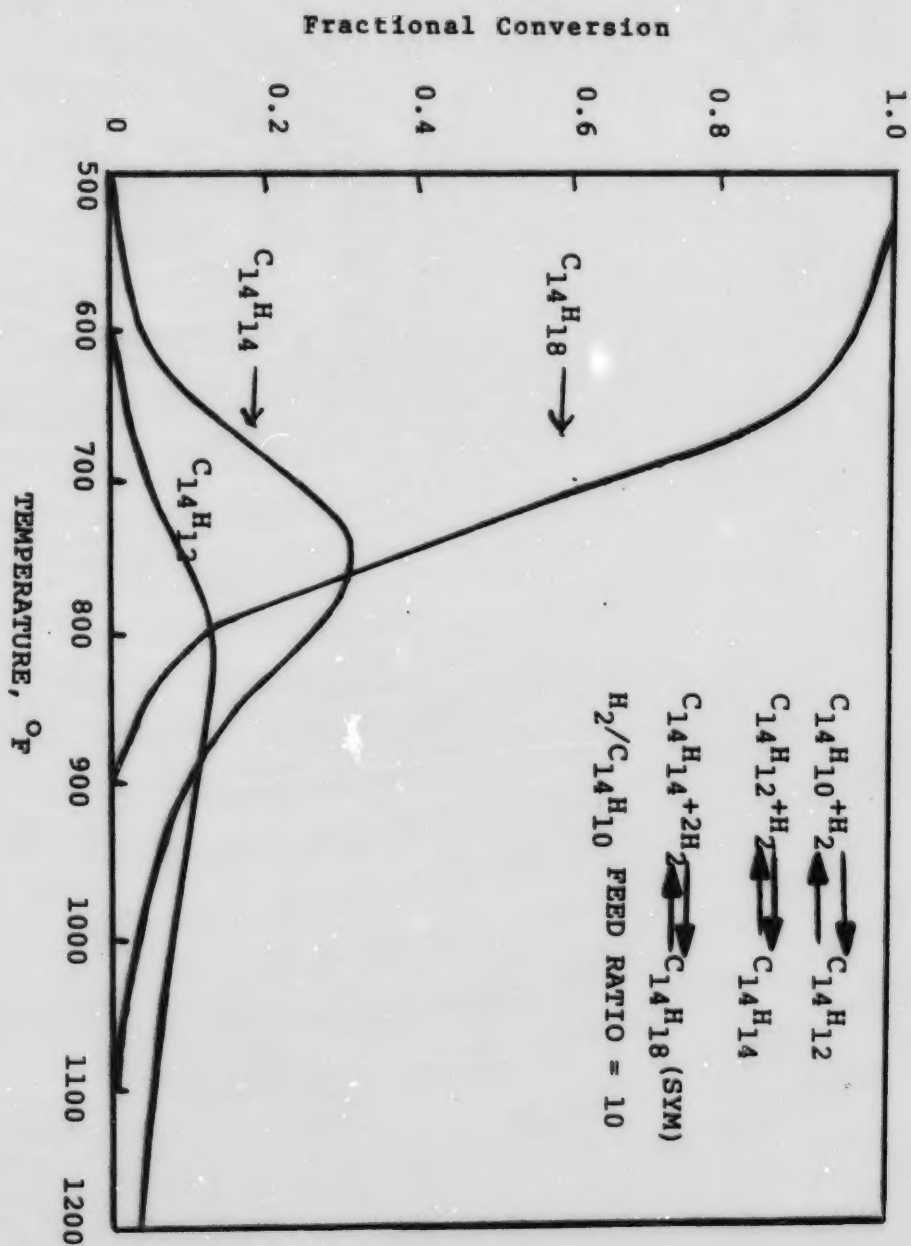


Figure 4. Equilibrium in the system $C_{14}H_{10}$, H_2 , $C_{14}H_{12}$, $C_{14}H_{14}$, $C_{14}H_{18}$, $P=1000$ psig.

III CATALYTIC HYDROGENATION OF MODEL COMPOUNDS

An excellent historical development of the work on the catalytic hydrogenation of polynuclear aromatic compounds is found in a review article by Smith (10). A study of the hydrogenation catalysts which included Group VIII transition metals have shown that hydrogenation reactions generally take place in steps so as to maintain a maximum resonance in any intermediate product even if this involves a shift in unsaturation from one ring to another. In the hydrogenation reaction of Phenanthrene, for example, the first product is observed to be 9,10-dihydrophenanthrene. Upon further successive hydrogenation the hydrogenation products would be tetrahydro, octahydro and perchydrophenanthrene. A very important observation has been made in that the ease of hydrogenation of polynuclear aromatics increases with increasing size of the molecule. The hydrogenation of the last ring proceeds with great difficulty. The rates of hydrogenation of benzene, naphthalene and anthracene over sulfided tungsten catalysts have been reported to be 100, 2300 and 6187 respectively.

Sullivan and co-workers (11, 12) hydrocracked phenanthrene over nickel sulfide-silica-alumina catalysts in a fixed bed flow reactor. Under the reaction conditions tetralin was the major product and the conversion was found to be low. It is important to note that traces of light alkanes were observed. A mechanism as depicted in figure 5,

involving partial hydrogenation, ring opening and a transfer of butyl group to another reactant molecule was postulated to explain the absence of large quantities of butane in the products.

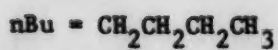
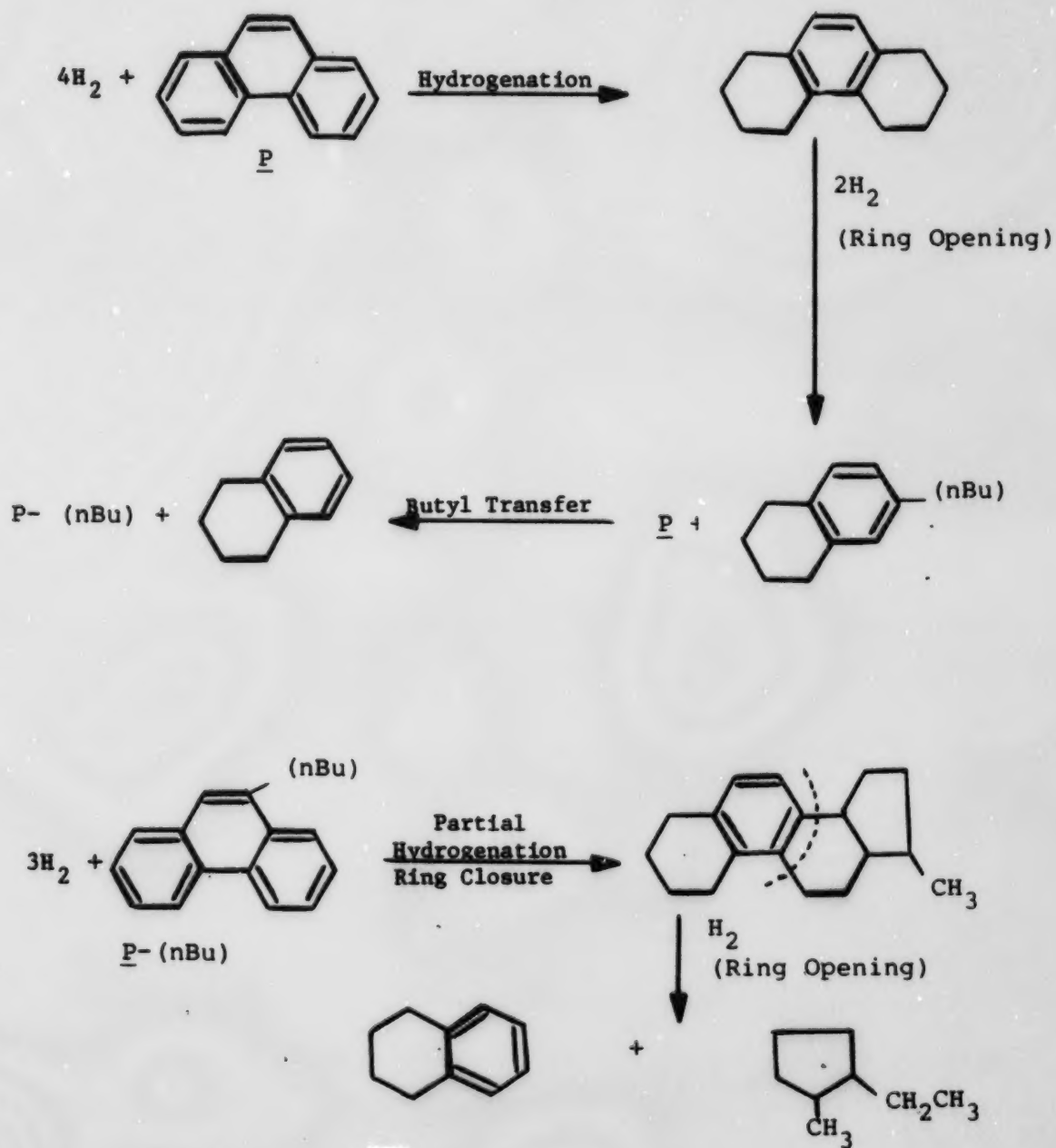


Figure 5 - Butyl Transfer Mechanism of Sullivan (11)

Qader and co-workers (13,14) hydrocracked naphthalene and anthracene over dual functional catalysts composed of the oxides of molybdenum, cobalt and nickel on silica-alumina with the main products observed being hydrogenated anthracene and naphthalene. The experiments were conducted in batch autoclaves. They (15,16) later reported the hydrocracking of naphthalene, anthracene and pyrene over catalysts consisting of a physical mixture of a hydrogenation component (sulfides and oxides of Co, Mo, Ni and W) and a silica-alumina catalyst. Batch autoclaves were used. Anthracene was hydrogenated and cracked to naphthalene derivatives which were subsequently cracked to benzenes. Similarly, pyrene was hydrocracked by a path which involved the formation of phenanthrene, which was in turn hydrocracked to naphthalene and ultimately to benzene.

The cracking reactions were accompanied by considerable isomerizations of saturated six member rings to methyl substituted five member rings. Such isomerizations are commonly observed in the presence of acidic catalysts, the mechanism of the hydrocracking of anthracene is explained in Figure 6.

Von Rumohrs (17) and Koelling studied the hydrogenolysis of anthracene and phenanthracene over supported nickel catalysts in a flow reactor at atmospheric pressure. A mechanism involving saturation and cracking of adjacent rings was postulated to explain the scarcity of benzene in the products, as shown in figure 7. High yields of methane were obtained.

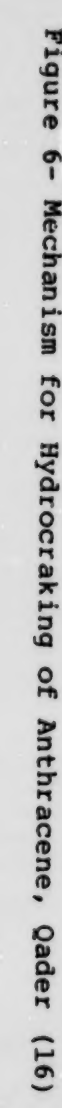


Figure 6- Mechanism for Hydrocracking of Anthracene, Qader (16)

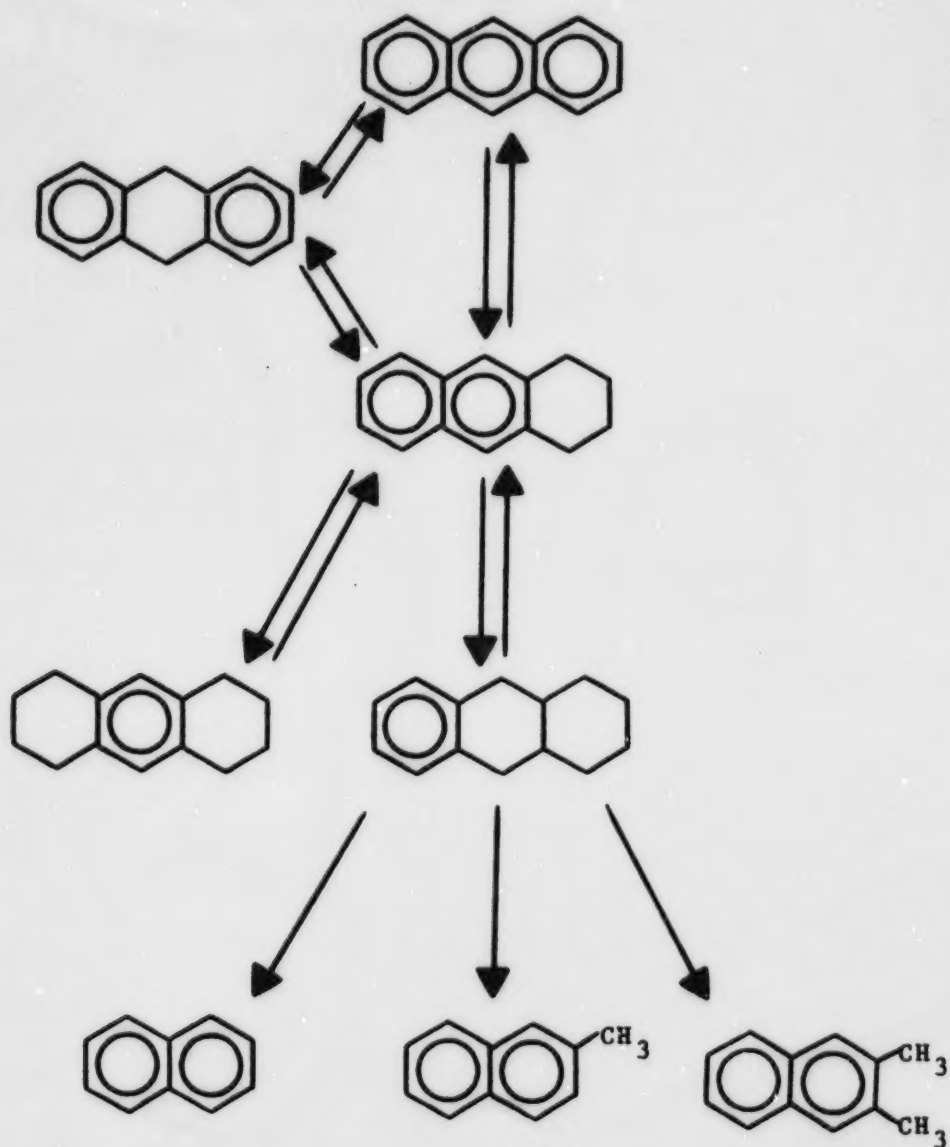


Figure 8. Hydrogenolysis of Condensed Ring Aromatics Over Supported Nickel.

Most studies on the hydrocracking of polyaromatics have utilized catalysts which include an acidic component, and consequently the cracking mechanism has generally been one involving carbonium ion intermediates. One would expect a substantially different product distribution from cracking by a path which involved free radicals. Carbonium ion and free radical mechanisms have been compared in earlier reviews (18,19).

Some insight into the types of products that might be obtained via a free radical hydrogenolysis of polynuclear aromatic compounds can be found in the study of Penninger and Slotboom (20) who investigated the high pressure thermal hydrogenolysis of phenanthrene. They found that both tricyclics are cracked mainly by stepwise hydrogenation of outer rings, ring opening and side chain cracking. Cracking within the side chain was extensive in contrast to the dealkylation of side chains normally observed over acidic catalysts. The path involving intermediate 1 dominates the reaction sequence since no 1 - substituted naphthalenes were detected, as depicted in Figure 7. In addition to terminal ring cleavage, they observed substantial quantities of ethylbiphenyl, biphenyl, and diphenylethane in their cracked products suggesting cracking at the central rings according to the scheme of Figure 8. The path involving the ethylbiphenyl radical is preferred. In a recent report Showronski and Recht (21) hydrocracked phenanthrene in the presence of a 50/50 mixture of

$\text{MOH/M}_2\text{CO}_3$ ($\text{M}=\text{Li, Na, K}$) in a batch autoclave at 475°C and 3000 psi. A large ratio (6/1) of catalyst to phenanthrene was employed and reaction times were varied up to one hour. While considerable hydrogenation and ring opening reactions were observed, the conversion to cracked product was low. The product distribution was similar to the thermal data of Penninger and Slotboom (20) as depicted in Figure 8. The cracked products were mostly alkynaphthalenes. Substantial amounts of 2-ethylbiphenyl and smaller quantities of diphenylethane were also present.

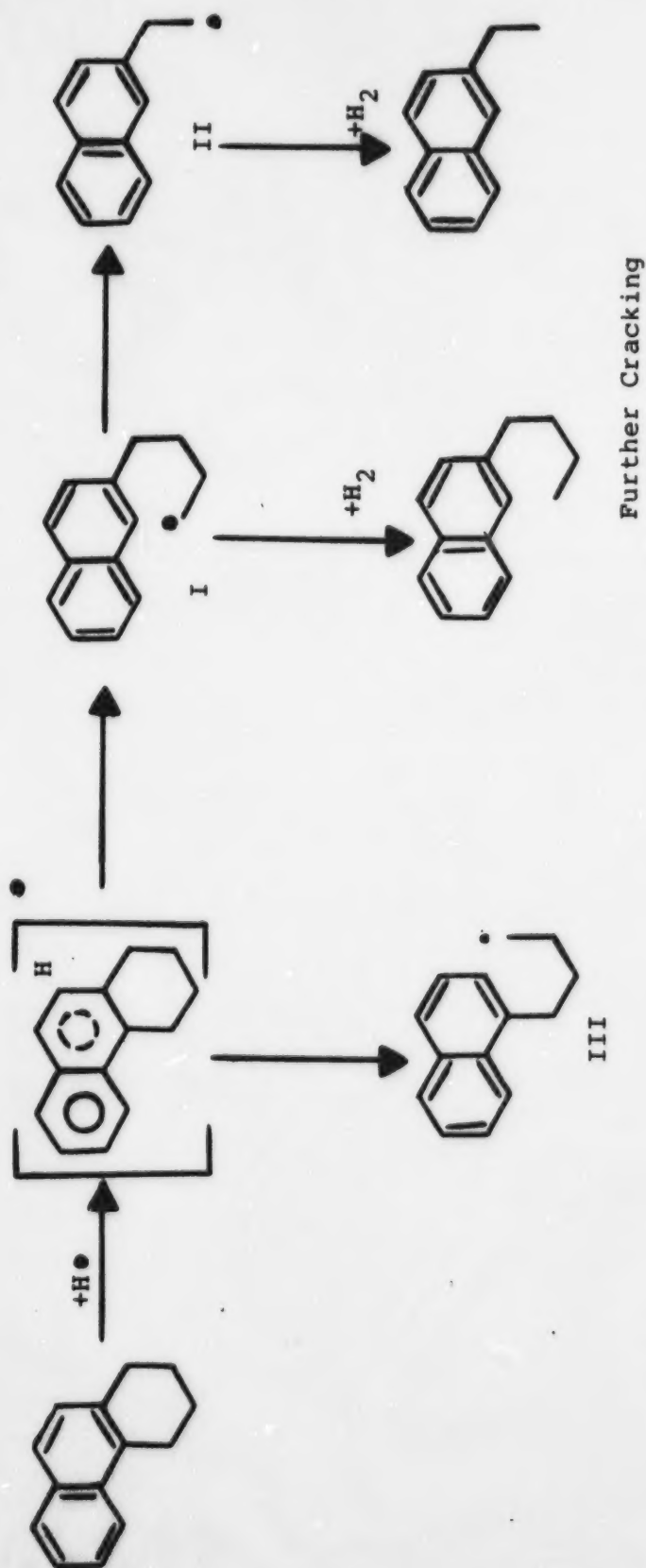


Figure 7A Thermal Hydrogenolysis of Tetrahydro Phenanthrene., Penninger and Slotboom (20)

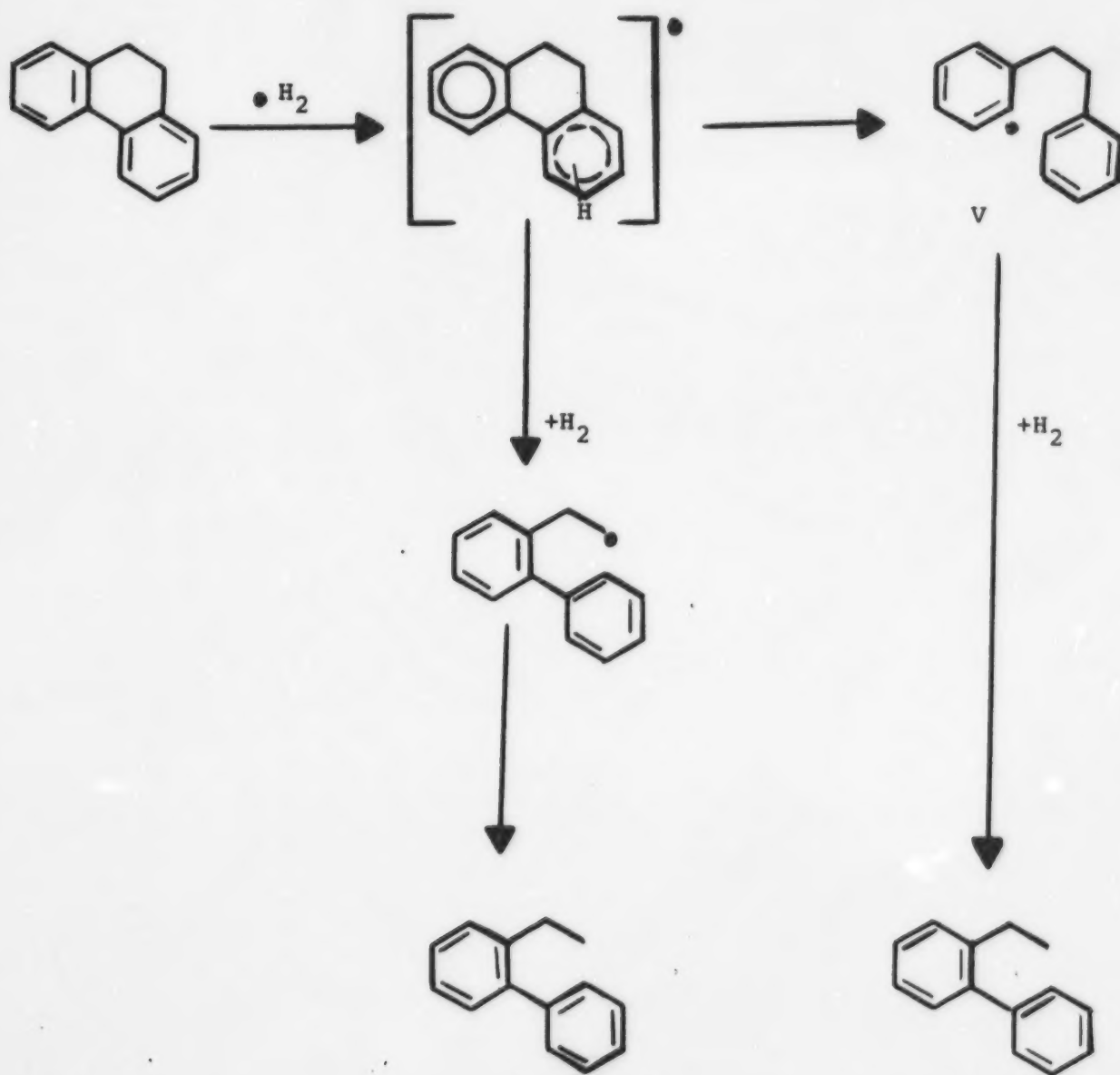


Figure 7B Thermal Hydrogenolysis of Dihydrophenanthrene, Penninger and Slotboom (20)

IV EXPERIMENTAL

IV.1 Flash Hydropyrolysis Unit

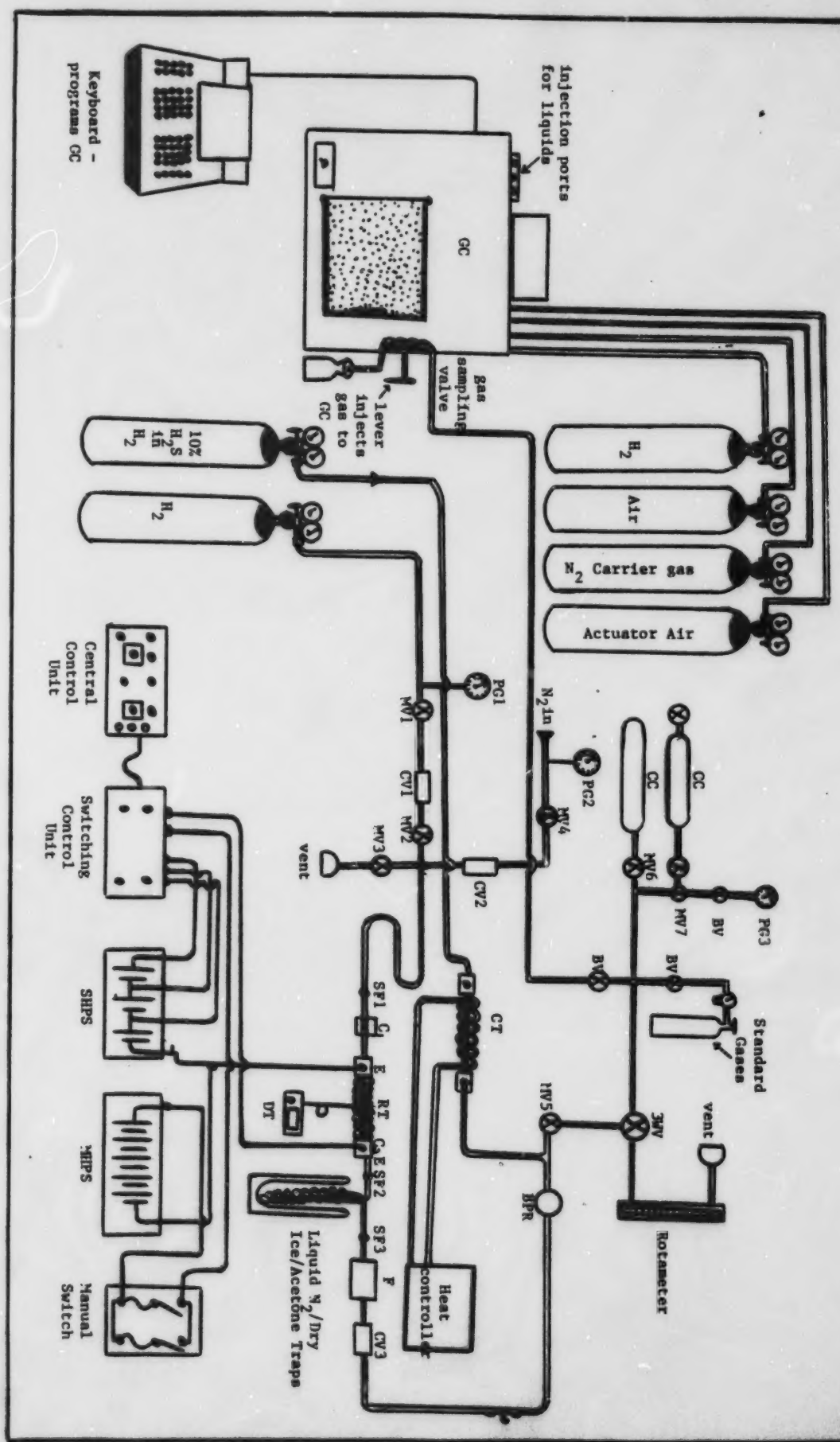
The assembly of the pressurized reactor and the associated components of Flash Hydropyrolysis Unit are shown in Figure 9. This Unit was designed and assembled in previous studies. Modifications were made in the present work to add more safety features and facilities for the analysis of gaseous products.

The FHP reactor (RT) consists of a 0.25" diameter X 15" long 304 stainless steel tube with a wall thickness of 0.035". Swagelok fittings are attached at each end and a type K thermocouple spot welded 6" from one end. The reactor is held in place by clamps C_1 and C_2 , one of which C_2 , at the right is also an electrical connection for the heating power supply which is connected to switching control unit as shown in the figure. The left end of the reactor tube is held loosely to allow for thermal expansion when it is heated. A removable electrical connection E completes the circuit for the resistance heating of the tube and is placed at a position such that the thermocouple is midway between it and the other fixed electrical connection. This allows the temperature measurement to be taken in the close vicinity of the sample.

NOTATIONS FOR FIGURE 9

PG	Pressure Gauge
MV	Metering Valve
CV	Check Valve
SF	Swagelok Fitting
F	Filter
BPR	Back Pressure Regulator
3WV	3-way valve
BV	Ball valve
CC	Collection Cylinders
CT	Reaction Tube
C	Clamp
E	Electrical Connection
K	Type K Thermocouple
DT	Digital Thermometer
T	Timer
SHPS	Secondary Heating Power Supply
MHPS	Main Heating Power Supply
GC	Gas Chromatograph

Figure 9 : Schematic Diagram of GCL's PMP Apparatus



The tube is heated rapidly by passing a large current through it and the temperature monitored by means of a digital thermometer linearized for use with a type K thermocouple. The heating current is controlled by the switching control unit which consists of a series of solenoids actuated by timers T1 and T2 in the central control unit. A manual switch in the main heating control circuit as shown in the figure can be used to disconnect the main power supply in the event that the solenoids in the main heating power supply circuit become welded and the reaction tube overheats.

The main heating which heats the tube rapidly is controlled by timer T1 in the central unit and the secondary heating which uses a lower voltage power supply to maintain the temperature for an extended period if necessary (2 to 10 seconds) is controlled by timer T2. The timers have a control unit to allow a large current from a bank of six heavy duty batteries to pass through the reactor tube. The battery voltage for the primary as well as the secondary heating power supply has switch selectable at 2 to 18 volts while the main heating power supply voltage and heating rate is changed by repositioning the positive battery terminal clamps.

IV.2 Safety Features

- The entire system has been pressure tested up to 1200 psig

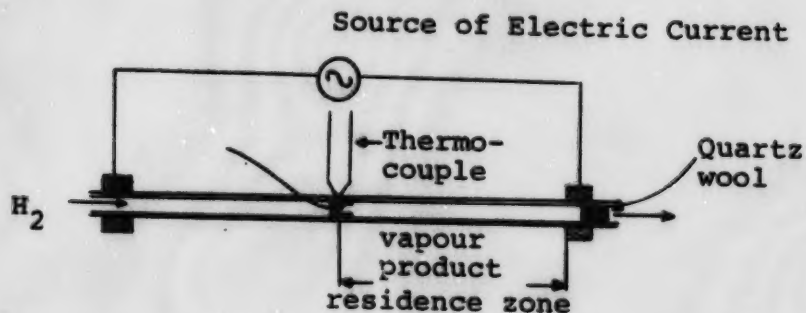
and reactor temperature of 1000°C . The temperature and pressure are kept below this.

- The heating control is custom designed and has a number of safety measures. The system employs solid state timing modules and electro-mechanic sequences switches
- The electrical switching control units have been modified to minimize solenoid welding in the event of high current.
- All circuitary is solid state and is sealed against open spark hazards.
- The metering valve MV allows one-way hydrogen flow.
- The reactor, collection system and valves facing the operator have been firmly mounted on a 4 X $5\frac{1}{2}$ foot board. Through a removable flexa frame foot plates the system is enclosed in a thick transparent plexiglass with access holes to the valves for their manipulations.

IV.2.1 Temperature Measurement

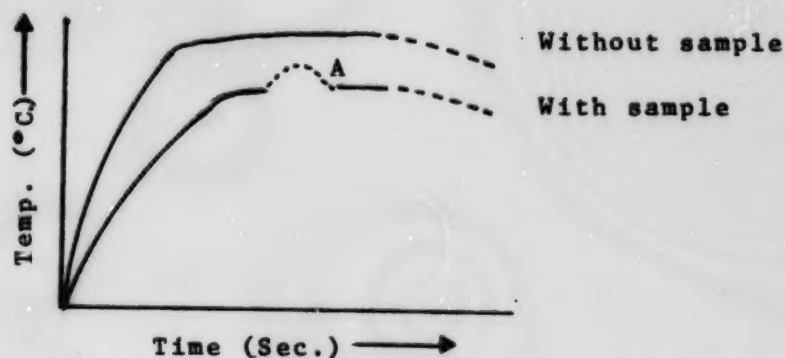
Temperature measurements are of considerable significance in the FHP experiments. A portion of FHP apparatus pertaining to the reactor heating and residence time is shown in the figure below for brevity:

Schematic Diagram of Reactor Heating, Residence Zone and Temperature Measurement



As stated earlier, the temperature measurements were made by means of fast digital thermometer linearized for use with type K, 0.001" chromel-alumel thermocouple, capable of higher heating rates (about one second to 800°C). The thermocouple lead was spot welded at the sample location. Only one thermocouple was employed to monitor the temperature and hold in memory, the maximum temperature attained. It must be mentioned that due to the delicacy of the thermocouple leads, some experimental inconveniences were encountered throughout the investigation. This included extreme care and on breakage, taking the reactor tube to the welding shop for spot welding. It usually occurred every three to four experiments.

In the absence or presence of a sample, the following temperature vs. time profile was observed:



In the period of sharp temperature profile, the temperature readings were too fast to be visually recorded. A slight rise in temperature such as A ($\sim 10^{\circ}\text{C}$) and then drop, was observed during the hydrogenation reactions which was attributed probably to the exothermic nature of the reactions. The temperatures reported are the maximum steady temperature. The accuracy of the thermocouple was tested by comparison with an Hg thermometer in an oil bath.

The thermocouple circuitry was designed to eliminate electromagnetic and electrostatic pick-up; however, in the sudden application of large currents, some small pick-up might have occurred. This was not tested.

The temperature in the vapour product residence zone was not measured. There could have been a variation in temperature.

The temperature during the initial sharp profile could not be measured. Its measurement required an oscilloscope or an extremely fast strip chart recorder. Unfortunately, this facility was not available at Guelph Chemical Laboratories.

IV.3 FHP Unit Operation

A schematic diagram of the modified FHP apparatus used in present studies is given in the figure 9. The mechanics of operation, beginning and termination of FHP runs are essentially the same as described in the previous report (22) by R.N. Pandey with the following exceptions:

- BV is connected directly to gas sampling valve assembly fitted on Hewlett-Packard GC with dual FID capability. Because of the availability of this feature, the analyses of gas products have been possible.
- Additional gas collecting cylinders CC have been added with valves on both ends to facilitate flushing of product gases formed, if required.
- The dry-ice acetone traps have been replaced with liquid N_2 traps and the connections from the reactor joints down to the trap inlet is electrically heated at temperatures lower than the reactor temperature just before quenching the products in the trap.
- In previous experiments (22) after connecting the reactor tube into the system the entire system was evacuated and flushed with nitrogen and re-evacuated to remove residual air. In the present method, nitrogen is not allowed to be in contact; instead, pure hydrogen is used for leak checks and for pressurizing the system. A moment before actuating the current valve MV5 is

manipulated so that the hydrogen pressure gets equilibrated to 1000 psig and then allowed to flow at a rate and current immediately actuated, temperature recorded and products quenched in the liquid N_2 trap, and the non-condensable products collected in the S.S. cylinders for analysis.

IV.4 Typical Experimental Run

During an experimental run, the cleaned and dried reactor tube and trap are first connected to the flow control system and the clamps and electrical connections attached. An approximately 10 mg sample is weighed accurately in a boat and mixed with a roughly equal amount of catalyst. Additional catalyst is tapped down on top of the catalyst sample mixture and the boat weighed again. Approximately 50 to 80 mg of catalyst is used.

The sample boat is inserted into the reactor tube (RT) at the thermocouple position by disconnecting the stainless steel tube at swagelok fitting SF1, inserting the boat with forceps and pushing it through the tube to the thermocouple position with a stainless steel rod. The fitting SF1 is then reconnected and the entire system including the gas collecting cylinders CC and the line MV1, MV2, SF, MV5 to MV6 via a 3-way valve 3WV. The evacuating force, a mechanical pump, is then disconnected and the valve 3WV is closed leaving the collecting cylinders,

associated line and standard gases line under vacuum.

The system is then gradually pressurized with Hydrogen by opening the metering valve MV1 cautiously and slowly so that the sample boat position is not disturbed or the catalyst is not blown out into the trap. The valve MV5 remains closed at this point and the system is pressurized with hydrogen at 1000 psig checked for leaks again and the swagelok fittings tightened if necessary.

The valve 3WV is directed to the rotameter and the hydrogen flow rate is adjusted to the desired value using metering valve MV5. The coiled trap is inserted into a liquid nitrogen dewar and a plexiglass shield put in place in front of the entire pressurized system. After about 10 minutes of flushing with hydrogen to displace any trapped air, the heating system is actuated and the maximum temperature is recorded.

After a few minutes the metering valve MV5 is closed and the liquid nitrogen trap is replaced by dry ice. The trap is allowed to warm to dry ice temperature and the flow is now directed via 3WV to one of the evacuated collecting cylinders. The trap is further warmed to -25°C and all the non-condensable gases are collected in the second cylinder. The hydrogen cylinder metering valve MV1 is then closed and the pressure allowed to drop. The plexiglass shield is removed and MV2 closed. When the

system pressure and flow drops to zero the reactor tube and the traps are then dismantled and removed.

The sample boat is pushed out of the reactor tube, washed with carbon disulfide and discarded. The reactor tube and trap are then rinsed several times with carbon disulfide. The CS_2 volume is made up to 10 ml or 25 ml in a volumetric flask and 3 μl samples of this solution injected into the gas chromatograph for liquid and solid product analysis. The reactor tube and trap are further rinsed thoroughly with hexane and acetone and dried by passing air through and over at 105°C . This tube is used in further experiments.

The gaseous product collected in cylinders CC are passed to the Hewlett-Packard chromatograph fitted with gas sampling valve and dual FID detectors. The gas analysis is accomplished by standard techniques of comparison of retention time with standard gases. The procedural details are described elsewhere in this report.

IV.5 Method for Sulfur Analysis in Sulfided Catalysts - Gravimetric Method

One gram of AR anhydrous Na_2CO_3 was placed in an iron crucible and 0.4 - 0.5 grams of catalyst was accurately weighed into it. About 5 - 6 grams of sodium peroxide was added and mixed well with a glass rod. The covered crucible was heated to 600°C in the muffle furnace for about

15 minutes. The furnace was allowed to cool to room temperature and the contents extracted with distilled water in a covered 600 ml beaker. The crucible contents were completely removed and the solution diluted to 300 ml of concentrated HCl added with stirring. The solution was filtered through Whatman #40 filter paper and washed 10 times with 15 ml portions of hot 1% Na_2CO_3 solution.

Concentrated HCl was added to the combined filtrate and washings in a 1 litre beaker until acid to methyl red and there were 2 ml added in excess. The solution was diluted to 600 ml, heated to boiling and stirred vigorously as 5 ml of hot 10% BaCl_2 solution was added dropwise from a burette. The solution was kept hot but not boiling for one hour in a covered beaker and filtered through Whatman #40 filter paper. The filtrate was tested with BaCl_2 to determine if further precipitations could occur. The precipitate was washed free of Chloride ions until 5 ml of filtrate gave a negative test with silver nitrate solution. The precipitate was dried and ignited with gradual heating with a previously ignited and weighed crucible. The percent sulfur was then calculated.

IV.6 Oxygen Flask Method

The sulfided catalyst was combusted in an oxygen flask containing water and hydrogen peroxide. The combustion products were absorbed in hydrogen peroxide to

ensure that all sulfur was present as sulfate. Titration with a standard barium perchlorate solution in alcoholic medium using thorin as the indicator was performed. Results were not satisfactory due to metallic interferences. In order to overcome this, samples containing interfering ions were passed through an ion exchange column, Rexyn 101 before titration. The sulfur content was then found to be in good agreement with the above gravimetric method. The catalysts analyzed by the gravimetric method are reported in table 1.

TABLE 1
Sulfur Content in the Sulfided Catalyst

Catalyst Cat. No.	Stated Composition	Reaction Time(hrs)	H ₂ S Flow Rate(ml/min)	%S Found
1 CoMo-0402 + 1/8	3% CoO 12% MoO ₃ on Al ₂ O ₃	3.5	250	9.1*
2 Ni-430 1 E 1/12	6% NiO 19% WO ₃ on Al ₂ O ₃	3.5	250	10.3**

* Theoretical Maximum = 9.30% S

** Theoretical Maximum = 10.46% S

IV.7 Sulfiding of the Catalysts

Cobalt molybdate catalyst, CoMo-0402T 1/8 E-365-1-13, and Nickel Tungsten, Ni-4301 E 1/12 Lot 56, were obtained from Harshaw Chemical Company, Elyria, Ohio.

The oxide forms of the catalysts were ground with mortar and pestle and packed into a 15 inch long and 0.25 inch O.D. stainless steel reaction tube, CT in figure 9, and were plugged at each end with glass wool. The tube was slowly heated to 400°C while passing a stream of 10% H_2S in H_2 obtained from Matheson of Canada Limited, Number U.F7174. Three and a half hours reaction time was allowed at 400°C. During sulfiding, the H_2S was directed to flow via valve MV5, 3WV to the rotameter and the vent. The temperature was monitored with analogic digital readout thermometer. After sulfiding reactions were complete the heat was turned off and the tube cooled to room temperature and was then flushed with N_2 gas. The sulfided catalyst was removed from the tube and stored in glass stoppered vials and analyzed for sulfur content.

IV.8 Precautions in Catalyst Sulfiding

In sulfiding the catalyst contact of pure hydrogen with the hot catalyst was avoided at all times, to prevent catalyst deactivation. This observation was made from a batch of catalysts sulfided and flushed with pure hydrogen

under hot conditions resulting in low conversions. During start-up of sulfiding care was taken that the temperature did not rise rapidly beyond the required temperature, as the sulfiding reaction is exothermic. The rapid heating during sulfiding may damage the catalyst.

IV.9 Equipment Operability Difficulties

Despite the various improvements, some difficulties were encountered in this investigation. Hydrogen Sulfide gas (10% H_2S and 90% H_2) is extremely corrosive to the line and parts of the equipment used. Leaks were found in back-pressure regulator, metering valve and the fittings in the rotameter.

To prevent the sticking of the solenoid, resulting in over heating of the reactor, it was found necessary to polish the contacts every two runs. This required dismantling to access the contacts.

Unfortunately, an error was discovered in the analysis of gaseous products due to leakage in the gas sampling valve assembly. The gas product analysis was completed first and liquid products kept frozen in glass vials to run in groups. Since gas products were discarded after analysis these runs could not be repeated for gaseous analysis after correcting the sampling valve assembly.

IV.10 Materials

Phenanthrene, Naphthalene were purchased from Aldrich Chemical Company. The Chrysene and perylene were purchased from Sigma Chemical Company. An elemental analysis of these materials was performed at Guelph Chemical Laboratories, and the results are given in table 1.

Table 1

Result of Elemental Analysis of Various PNA's
Used in this Study

Compound	%C	%H
Phenanthrene	94.32	5.70
Naphthalene	93.78	6.44
Chrysene	94.22	5.26
Perylene	95.43	4.61

These results indicated that the compounds were of high purity.

High purity hydrogen, hydrogen sulphide gas (10% H_2S in H_2) and pure standards methane, ethane, propane, Isobutane N-pentane in a mixture were obtained from Matheson of Canada. The oxide forms of the catalysts were obtained from Harshaw Chemical Company, Elyria, Ohio. The lot number and the method of sulfiding the catalysts have been

described in the above section IV.7.

IV.11 Analytical Procedure

Carbon disulfide was used as a solvent to dissolve the liquid and solid products trapped in the cooling coil. The trap was washed several times with the solvent to extract the products. The products were then analyzed on a Hewlett-Packard Gas Chromatograph, model 5831A fitted with dual FID detector and temperature programming capability. The carrier gas was nitrogen.

The gas samples were introduced into the Gas Chromatograph through a gas sampling valve. A calibration of the instrument was undertaken using a mixture of standard methane, ethane, propane, butane and pentane. The response was determined for each gas for a sample loop of known volume. The same loop was used for product gases. The operating conditions for the Gas Chromatograph are given in Table 3.

Table 3

Gas Chromatographic Conditions for the
Analysis of FHP Products

Conditions	Low Boiling Components	Gases	High Boiling Components
Column used	10'X0.125"OD 10% OV-101 100/120 Supelcoport	Activated Alumina Coated with 17% β,β' Oxydipropio- nitrile 10'X0.125OD 100/120	10'X0.125" O.D. OV-101 100/120 Supelcoport
Detector	FID	FID	FID
Detector Temperature	250°C	150°C	300°C
Oven-Column Temperature	100°C	25°C	250-300°C
Carrier Flow	25 cc/min	20 cc/min	25 cc/min
Injection Temperature	285°C	25°C	300°C
Sample Size	3 μ l	5 cc	3 μ l

In some earlier experiments two other columns were used. For low boiling components column 20' X 0.125" OD

10% FFAP supelcoport 100/120 and for high boiling components 6' X 0.125" OD 5% SE30 were used. However, the column 10% OV-101 was found to separate the low as well as high boiling components under the conditions of table 3.

IV.12 Typical Analytical Run

FHP runs were conducted as described previously in section IV.4. Executed FHP run was quenched in a liquid nitrogen trap. The trap was warmed to dry ice/acetone bath and then to -25°C . With the hydrogen flowing, the product gases were collected in measured and evacuated stainless steel cylinders. The product gases were then passed via gas sampling valve assembly to the gas Chromatograph and were analyzed by standard techniques. The peak areas were measured and compared with standard gases for quantitative analysis.

The quenched products in the trap were dissolved in carbon disulfide and analyzed on the appropriate column as given in the above table. Prior to gas and liquid product analysis it was ensured that the response factors for each product component was linear. Calibration curves were constructed by injecting known volumes of pure component and measuring the resulting peak areas. In the unknown mixtures, these curves were used to compute the composition from the measured peak areas.

For the quantitative analysis of the products, it was necessary to check the linearity of the FID detector over the range of the concentrations found in the product. The linearity of the detector was checked by injecting solutions of sample in carbon disulfide at different concentrations

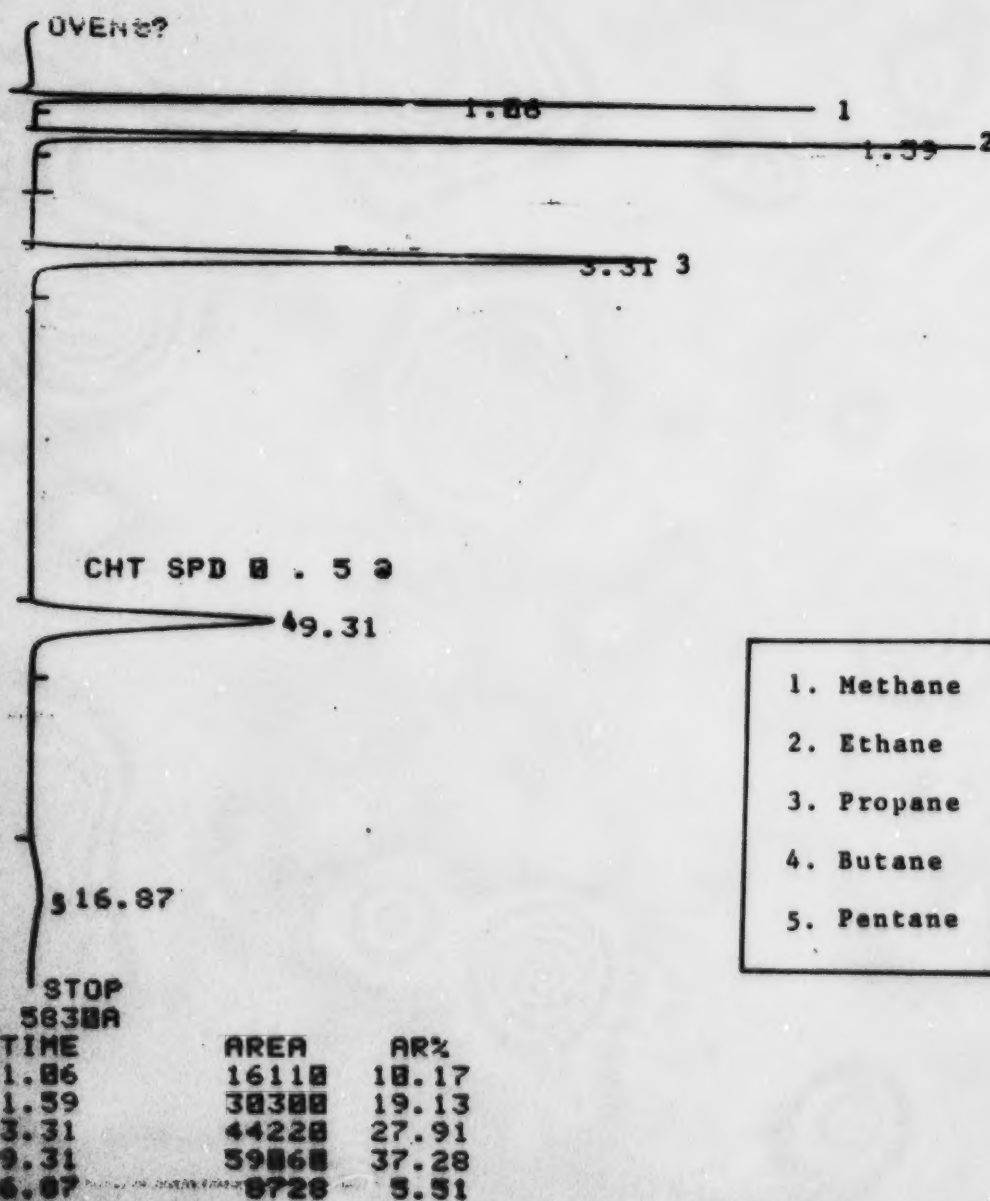
and plotting the observed area vs the sample concentrations in parts per million. Prior to undertaking liquid product analysis, a quantitative analysis of a standard mixture of products, made from benzene, toluene, ethyl benzene, xylene, decalin, tetralin, naphthalene, biphenyl, dihydrophenanthrene, phenanthrene, chrysene and perylene were analyzed. The analyzed and standard concentrations were in agreement within $\pm 10\%$.

GC-MS analysis of the FHP liquid products are given in the result section. A number of minor products for which commercial standards were not available could not be quantified.

Some problems were encountered in the analysis of gaseous products. The boiling point of C_1 to C_5 product gases range from -164°C to $+36.07^{\circ}\text{C}$ respectively. The gaseous mixture quenched with liquid products at liquid nitrogen temperature required careful warming up of the trap so as to allow the collection of gases without losing the volatile liquids. In a number of FHP runs conducted during the development of base conditions, satisfactory analysis of gases was not achieved. A standard gas mixture $C_1 - C_5$ mixed with high pressure hydrogen was passed through liquid nitrogen trap and complete separation technique for gases developed. In addition the gas sampling valve was found to be leaking, and was corrected. Satisfactory results were then obtained. Two standard gases, $C_1 - C_5$ one in the

order of 10 ppm and the other 100 ppm were analyzed to check the linearity of the FID response. Under the conditions employed, see table 3, the separation and linearity was good. The chromatograph of 100 ppm of standard mixture is given in figure 10

Figure 10: Typical Separation of Gases C₁ - C₅ From
100 ppm Standard



IV.13 Calculations for Carbon Balance

The carbon material balance was calculated manually. This offered an alternative to the total material balance since the latter required a precise knowledge of the hydrogen consumed. A considerable amount of analytical time was required. The dual FID temperature programming was not working satisfactorily and the column conditioning in the isothermal mode required longer time. It must be mentioned that many analytical runs stored at low temperatures for liquid product analysis were unsuccessful mainly because of solvent contamination. The following method was used for computing the mass of carbon in the product:

- Let W_i = Weight of the i^{th} component in the product
- WC_i = Weight of carbon in the i^{th} component
- NC_i = Number of carbon atoms in component i
- MW_i = Molecular weight of component i
- W_0 = Weight of feed in the reactor
- WC_0 = Weight of carbon in the feed
- $WCRP$ = Total weight of carbon recovered in the product

$$\text{Then, } WC_i = \frac{12 \times NC_i \times W_i}{MW_i}$$

For Phenanthrene, for example,

$$WC_0 = \frac{12 \times 14 \times W_0}{178.24}$$

The total weight of carbon recovered in the products is given by:

$$WCRP = \sum WC_1 \text{ (liquid)} + \sum WC_1 \text{ (gas)}$$

From the measured quantities, the ratio of WC_1 to WC_0 was calculated.

IV.14 Recovery Studies

The recovery studies were accomplished using pure model compounds and subjecting it to similar experimental conditions described for taking experimental runs but without a catalyst.

IV.15 Possible Carbon Deposition

Unsulphided catalysts were analyzed for carbon impurities. The spent catalyst was also filtered from the solvent, dried and analysis of carbon performed. These results indicated that the carbon deposition was not taking place despite the high temperature employed. A good carbon balance should therefore be expected via gaseous and liquid product analysis in executed PHP runs.

V RESULTS

V.1 Hydrogenation of Naphthalene

The results of hydrogenation of naphthalene over sulfided Ni-W catalysts and sulfided Co-Mo catalysts are presented in tables 4 to 8 .

The chromatograms of the typical gaseous and liquid products used for quantitative analysis are given in figures 14 and 16. A standard sample of 10ppm gaseous mixture is included in the chromatogram for comparison.

A sample in carbon disulfide solution of one of the naphthalene FHP reaction mixture with Co-Mo sulfided catalyst was analyzed by GC/MS. The number of peaks observed using capillary column are given in figures 11 to 13. The mass spectrum of the base peaks are given in Appendix II. The identification of peaks of figures 11 to 13 are given in Table 4.

GC/MS Conditions For Figures 11, 12, and 13

Instrument : Hewlett-Packard 5790
 Column : 30m x 0.25 DBS fused silica capillary
 Flow Rate : 1 ml/min He
 Injection Temperature: On column
 Program Condition : 20°/min; final temp.: 325° Celcius
 Injection Volume : 1 μ l

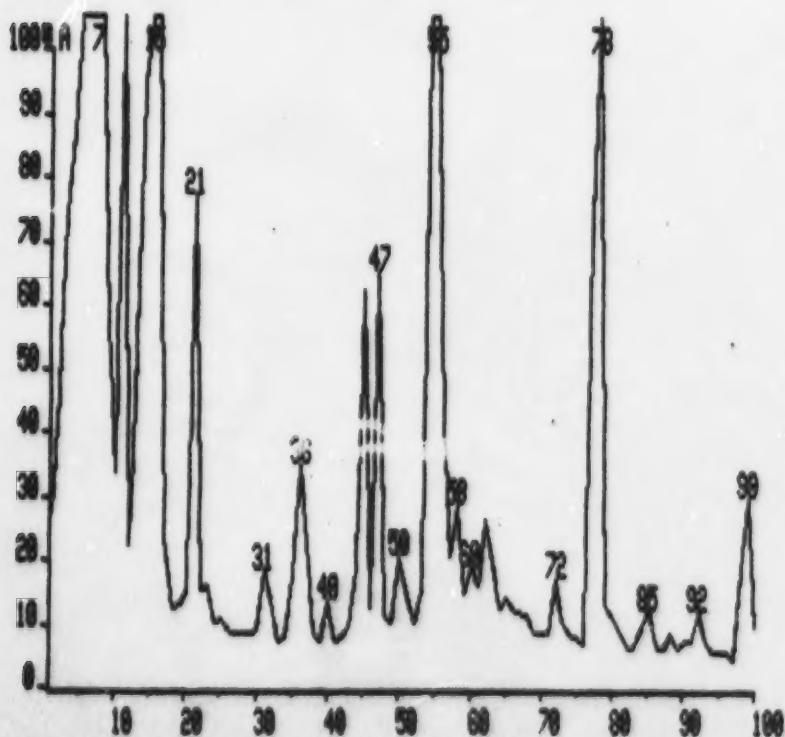
MS Conditions (See Apendix II)

Multiplier Voltage : 1600 e.m.v.
 Scan Speed : 1 scan/second
 Scan Range : 50-350 mass units

Figure 11

Capillary Chromatogram of the FHP Products
 Of Naphthalene over Ni-W Catalyst

FHP123 #1-810
 A : ATIC



1.00
 1007

Capillary Chromatogram of the FHP Products
Of Naphthalene over Ni-W Catalyst

FHP123 #1-810

A:ATIC

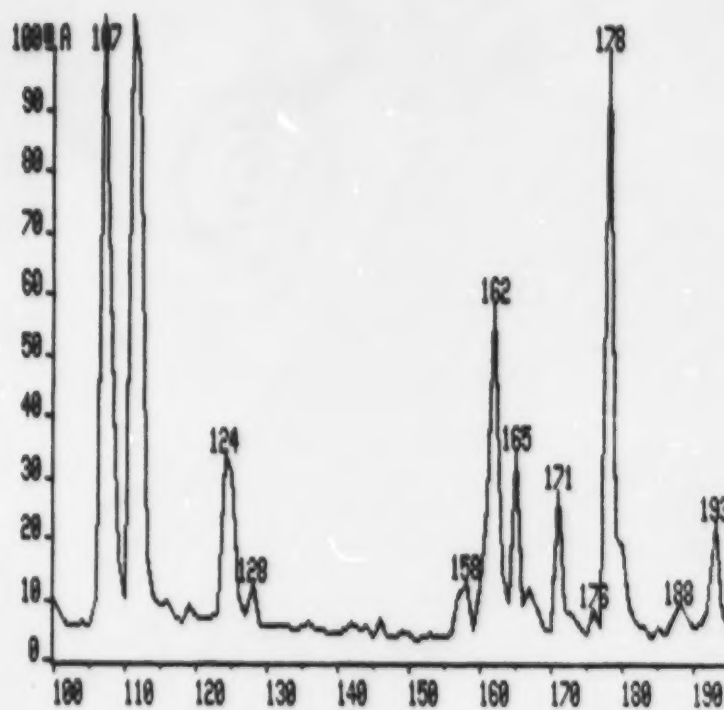


Figure 13

Capillary Chromatogram of the FHP Products
Of Naphthalene over Ni-W Catalyst

FHP123 #1-810

A:ATIC

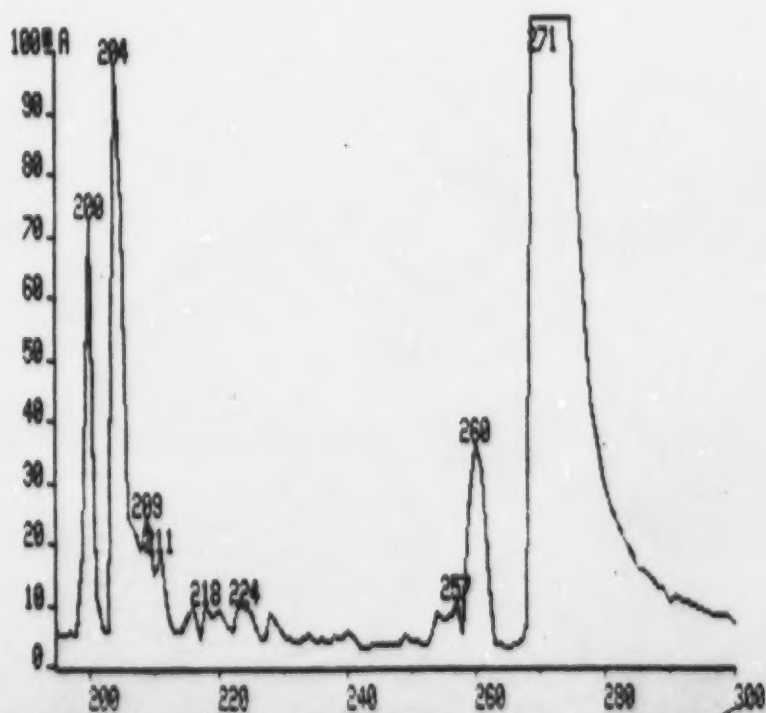


TABLE 4
Qualitative Analysis of Liquid
Products From FHP of Naphthalene

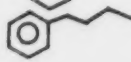
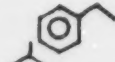
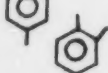
Spectrum (Peak #)	Retention Time (min)	Molecular Ion m/e	Base Peak	Formula	Identification (Tentative)	
7	0:15	78	78	C_6H_6	Benzene	
11	0:20	100	57	C_8H_{18}	Alkylated pen-	
15	0:24	98	57	γC_8	taness & hexanes 2,2,4-Trimethyl pentane or 2,2- Dimethyl Hexane	
31	0:44	98 or more	56			
36	0:50	98 or more	57		Cyclohexane deri-	
40	0:55	98 or more	55		vative mixed with carbon disulfide	
45	1:01		71			
47	1:03		57		Mixture of uniden-	
50	1:07		70		tifiable hydrocar-	
55	1:14	92	57		bons (molecular ion cannot be seen)	
58	1:16	134?	57		Toluene	
60	1:19	112 or more	76		n-butylbenzene	
78	1:41	170	129		C_8 or higher hydrocarbon	
107	2:16	106	91		Benzene derivative	
111	2:20	106	91		Ethyl Benzene	
124	2:20	106	91		P-xylene	
158	3:17	120	91	C_9H_{12}	O-xylene	
162	3:22	120	105		N-propyl benzene	
165	3:26	120	105	C_9H_{12}		
171	3:33	120	105		May be 1-methyl-	
178	3:41	120	105		2,3,4 ethyl benz-	
193	3:59	120	105		ene or various	
271	5:34	128	127	$C_{10}H_8$	trimethyl benz- enes	

Figure 14
Chromatograms of Liquid FHP Products
Of Naphthalene Using Co-Mo- Sulphided Catalysts

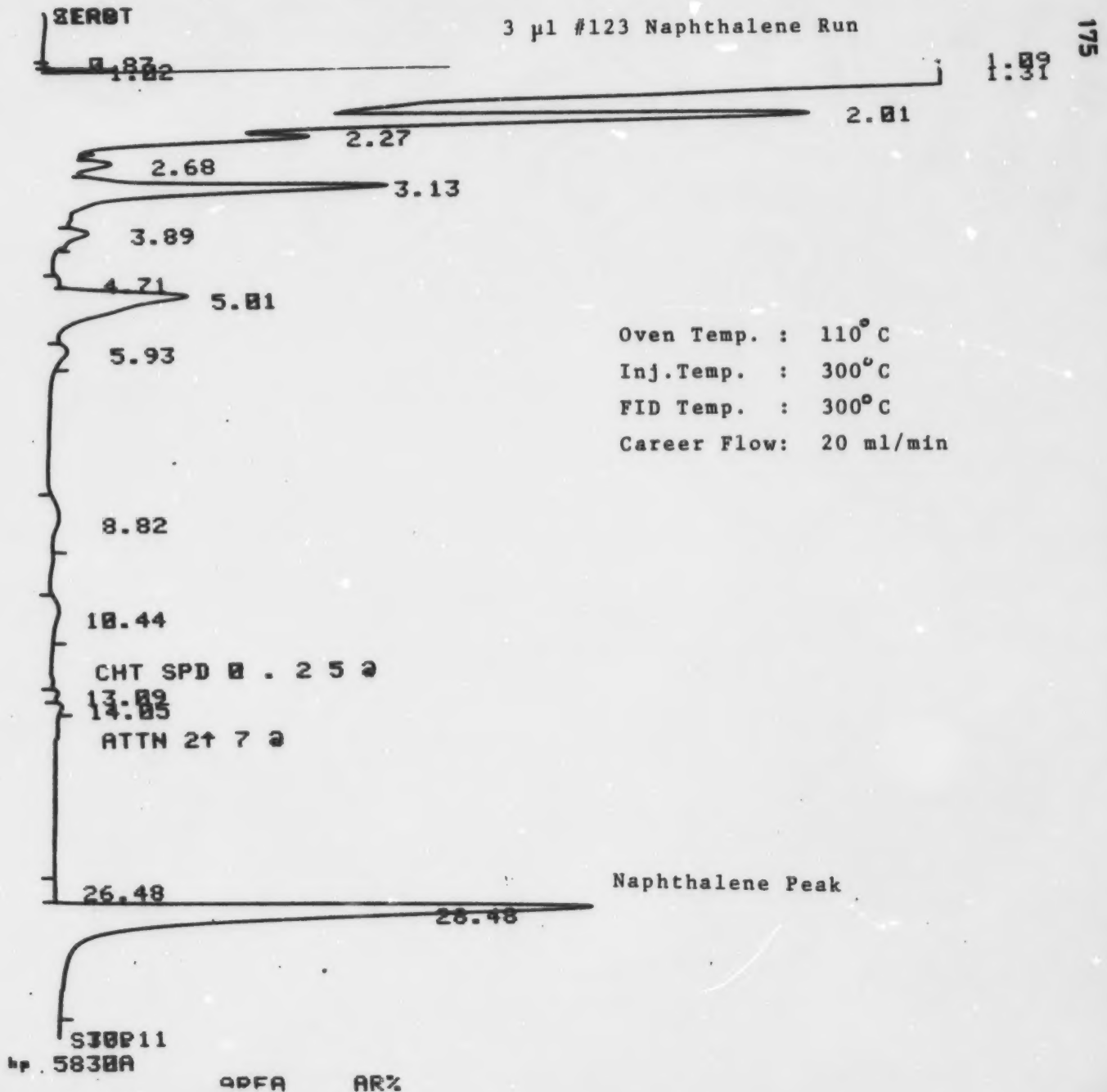


Figure 15
Chromatograms of Liquid FHP Products
Of Naphthalene Using N₄-W Sulphided Catalyst

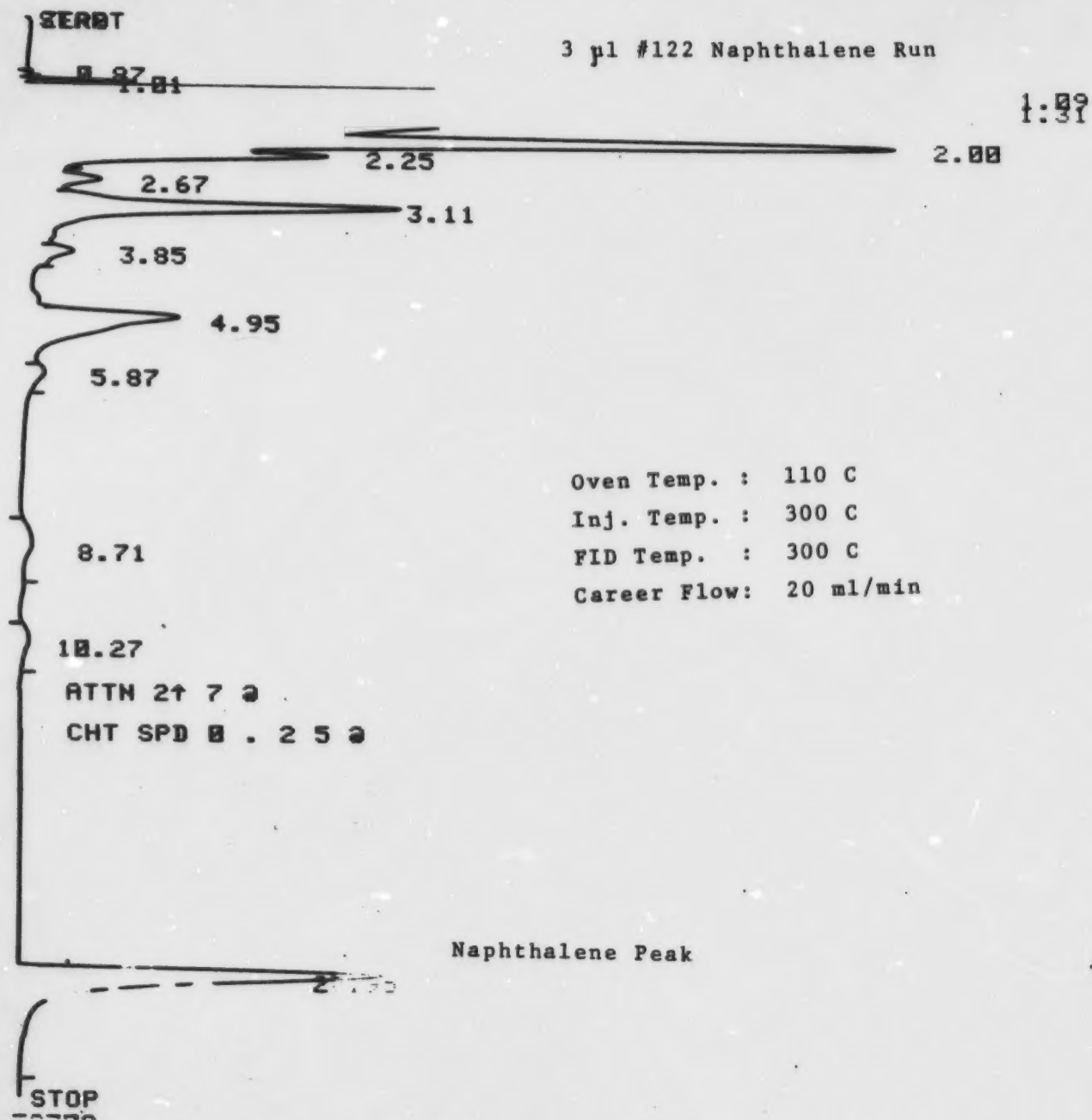
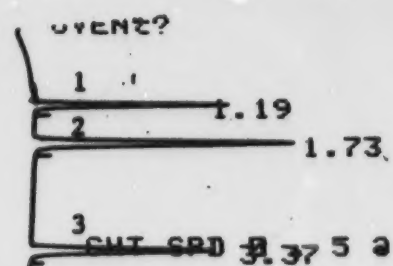


Figure 16
Chromatogram of Standard and
FHP Product Gases

(A) Standard



1. Methane
2. Ethane
3. Propane
4. Butane
5. Pentane

(B) Products

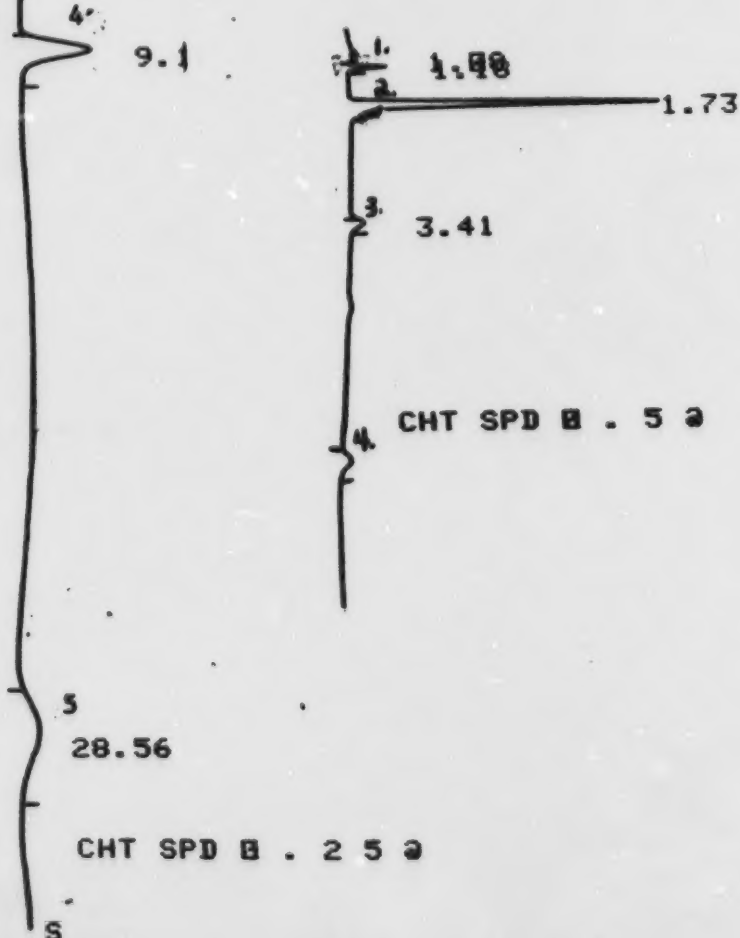


TABLE 5
Hydrogenation of Naphthalene
Without Catalyst
(Recovery Studies)

Expt. No.	Residence Time (sec.)	Naphthalene (in mg)	Catalyst/N* Ratio	Reaction Temp. (°C.)	pH ₂ (psig)	% Unreacted Naphthalene
N1	1	7.56	N11	700	1000	97.6
N2	-	11.36	N11	744	1000	87.4
N3	1	9.00	N11	752	1000	102.0
N4	2	8.00	N11	589	1000	95.6

*N-Naphthalene

TABLE 6
Development of Base Conditions For
Hydrogenation of Naphthalene Over Sulfided
N₁-W and Co-Mo Catalysts

Expt. No.	Residence Time (sec.)	Naphthalene (in mg)	Catalyst/N Ratio (wt/wt)	Reaction Temp. (°C.)	PH ₂ (psig)	% Total Yield
N5	1	4.62*	5.00	700	1000	60.0
N6	1	4.73*	10.00	800	1000	56.2
N7	1	6.02*	8.00	750	1000	62.5
N8	1	6.24*	6.00	800	1000	60.8
N9	1	8.09**	5.00	800	1000	65.0
N10	2	10.00**	8.00	750	1000	60.2

N=Naphthalene

*=N₁-W Sulfided Catalyst

**=Co-Mo Sulfided Catalyst

TABLE 7
Reaction Conditions for the Flash Hydropyrolysis
Of Naphthalene Over Ni-W-S/Alumina
And Co-Mo-S/Alumina

Expt. No.	Residence Time (sec.)	Catalyst Used	Naphthalene (in mg)	Catalyst/N Ratio (Wt/Wt)	Reaction Temp. (C.)	PH ₂ (psig)
N11	2	Ni-W-S	7.68	10.00	752	1000
N12	2	Co-Mo-S	7.56	10.13	791	1000

N-Naphthalene

TABLE 8

Major Product Yields in FHP of
Naphthalene: % Carbon by Weight

Products	Experiment Number	
	N11	N12
Methane	3.78	4.80
Ethane	19.27	21.42
Propane	2.25	2.50
Butane	1.80	2.40
Pentane	--	--
Unidentified merges with CS ₂	?	?
Benzene	9.95	8.90
Alkylated Hexanes	4.80	5.40
Toluene	4.60	4.80
Xylenes	6.40	5.60
Alkylated Benzenes	?	?
Naphthalene	37.80	45.60
TOTAL	90.65	101.42

V.2 Hydrogenation of Phenanthrene

The results of hydrogenation of phenanthrene over sulfided Ni-W and sulfided Co-Mo catalysts are presented in tables 9 to 15.

The chromatograms of a typical liquid product including phenanthrene as reactants are given in figures 18 and 19. For quantitative analysis, chromatographic conditions were used such that the low and high boiling components were separated.

Two FHP experiments, one with Ni-W-S catalyst and the other Co-Mo-S catalyst were also analyzed by GC/MS. The number of peaks observed using capillary column are given in figures 20 to 29. The mass spectrum of the base peaks are given in Appendix III. The identification of the peaks of figures 20 to 25 are given in table 9.

FIGURE 17Chromatogram of Solvent, Carbon Disulfide

hp 5830M

RTIME

4.84

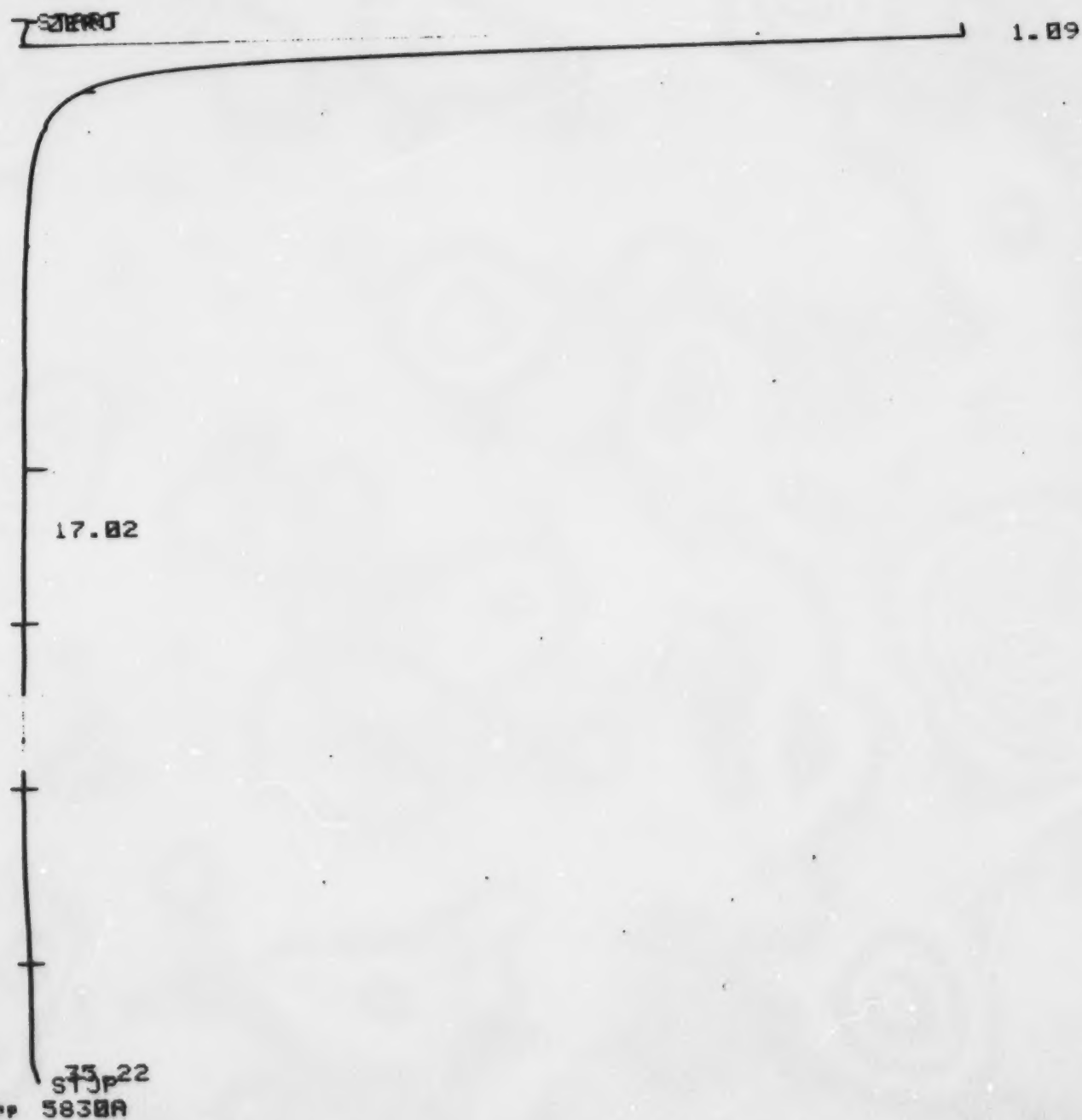
AREA

238800

AR%

100.00

61



ZERO

FHP 89

1.89

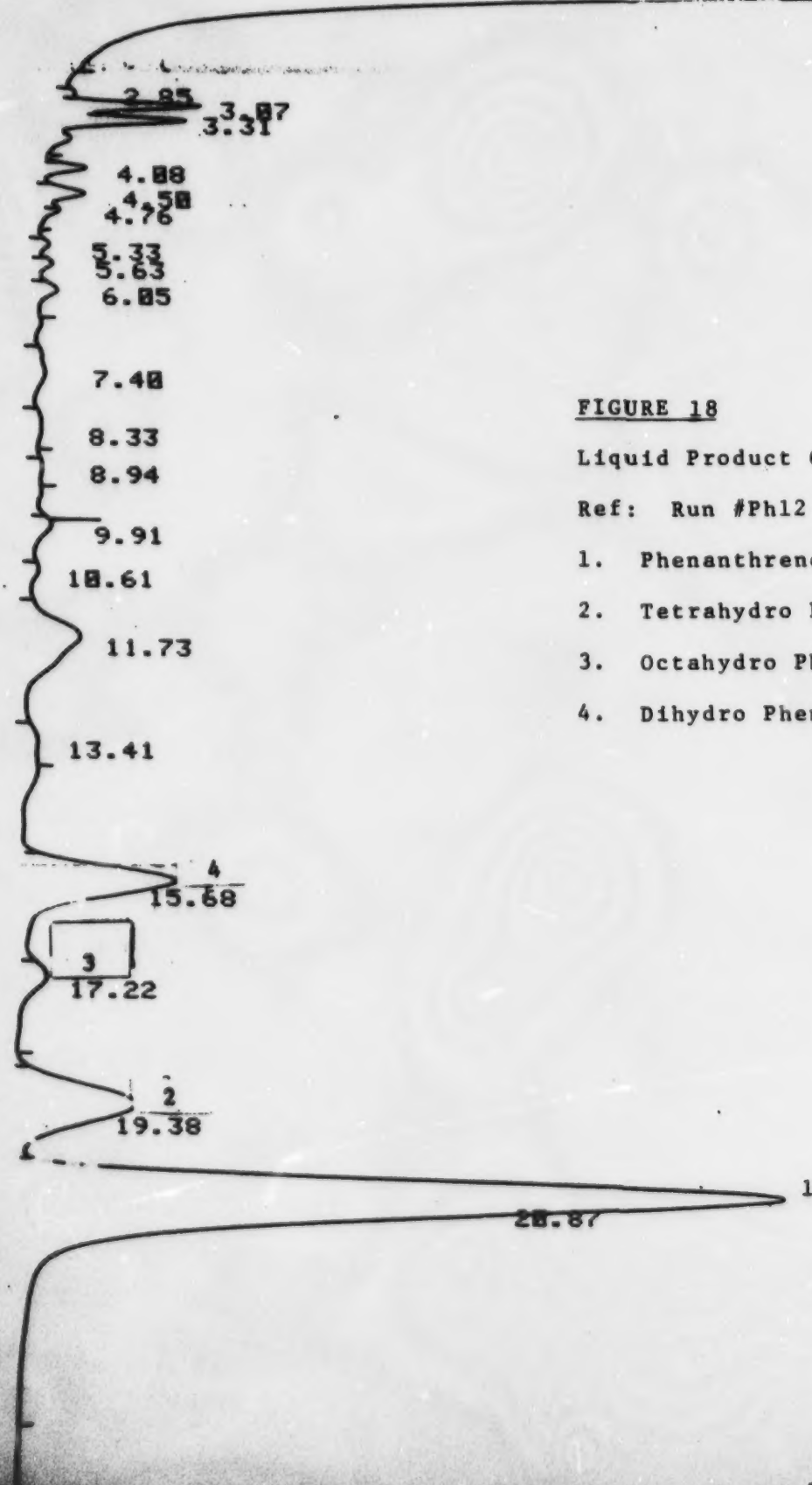


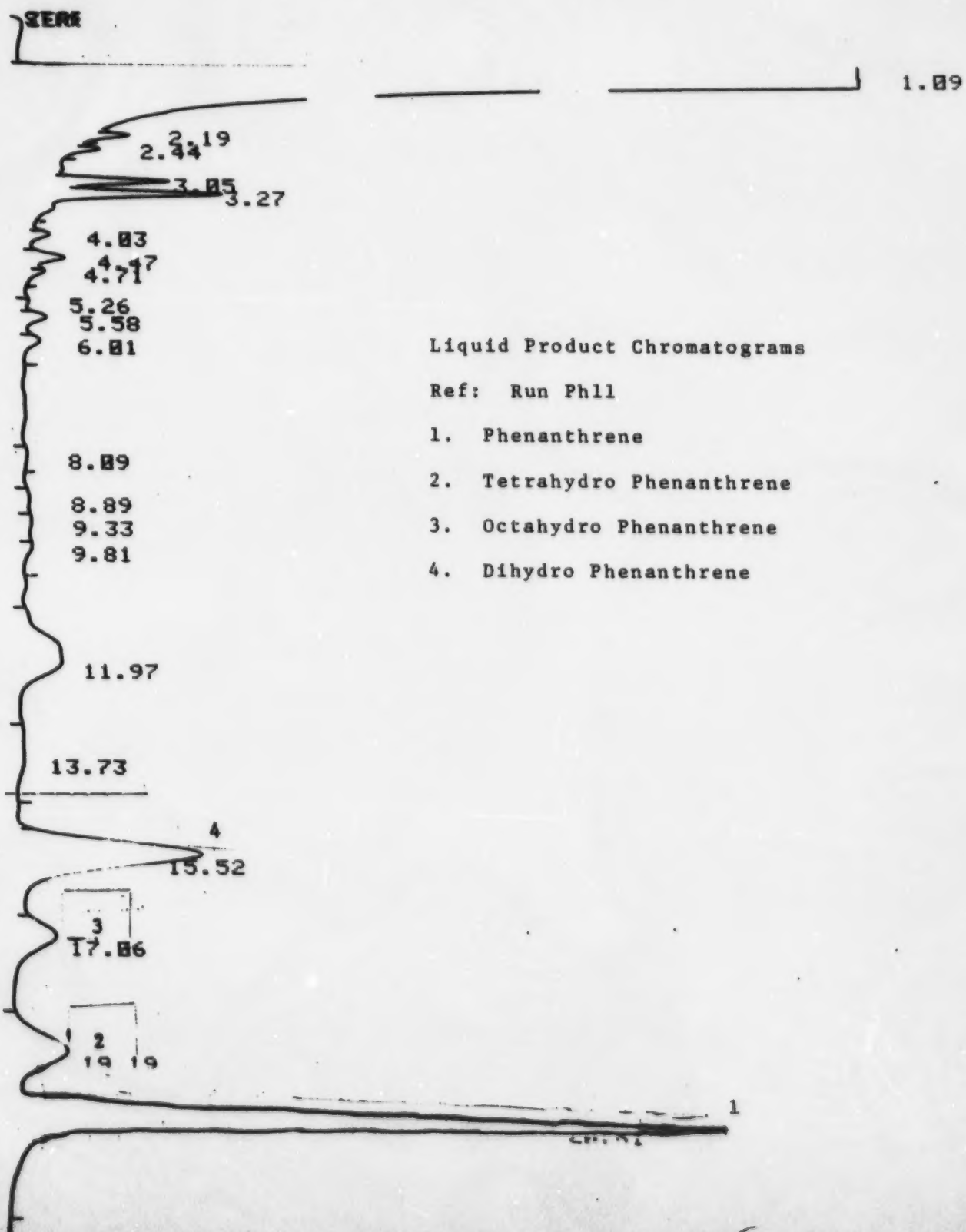
FIGURE 18

Liquid Product Chromatograms

Ref: Run #Ph12

1. Phenanthrene
2. Tetrahydro Phenanthrene
3. Octahydro Phenanthrene
4. Dihydro Phenanthrene

FIGURE 19



GC-MS Conditions

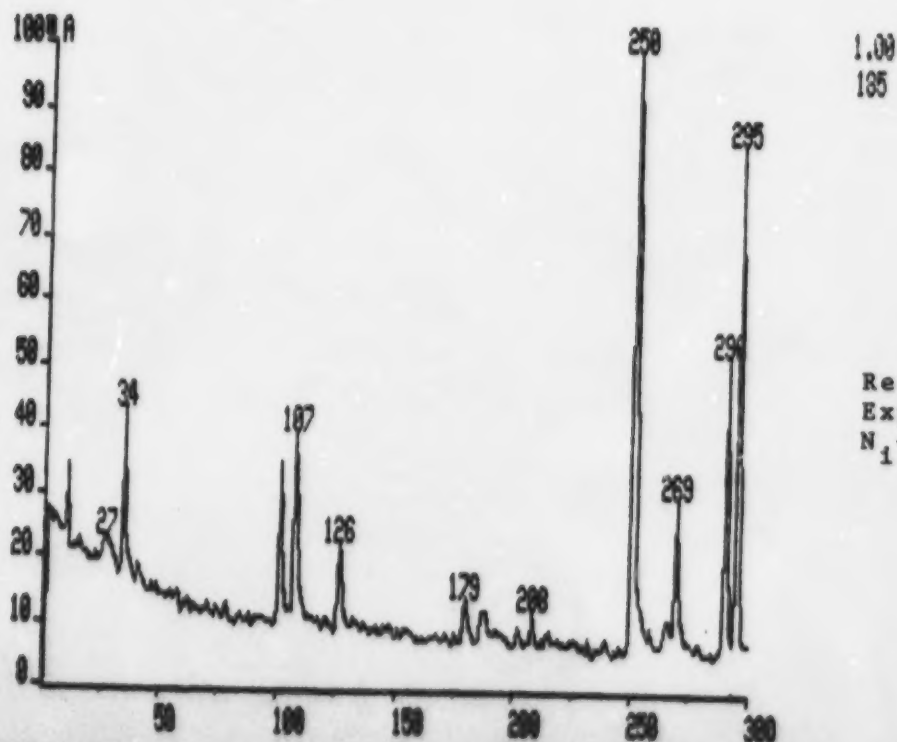
Instrument : Hewlett-Packard 5790
Column : 30m x 0.25 DBS fused silica capillary
Flow Rate : 1 ml/min He
Inject Temp. : On Column
Program Conditon : 20 /min; final temp.: 325 Celcius
Injection Volume : 1µl

MS Conditions (See Appendix III)

Multiplier Voltage: 1600 e.m.v.
Scan Speed : 1 scan/sec
Scan Range : 50-350 mass units

FIGURE 20

R99 01-1900
A :ATIC



Ref:
Expt. No. Ph10
N₁-W-S Catalyst

FIGURE 21

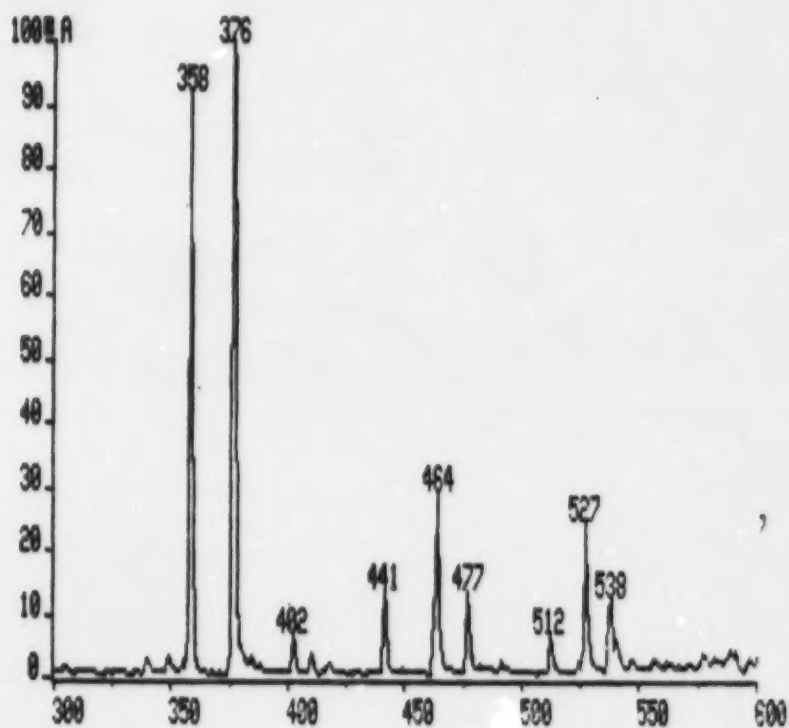
R90 #1-1900
A :ATIC1.00
1186

FIGURE 22

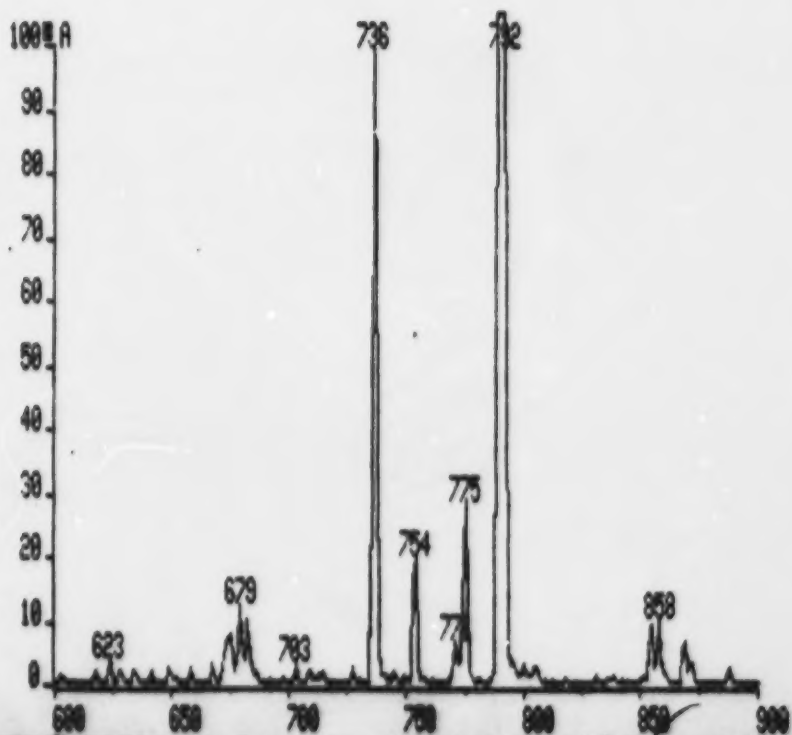
R90 #1-1900
A :ATIC1.00
5269

FIGURE 23

65

R90 #1-1900
A :ATIC

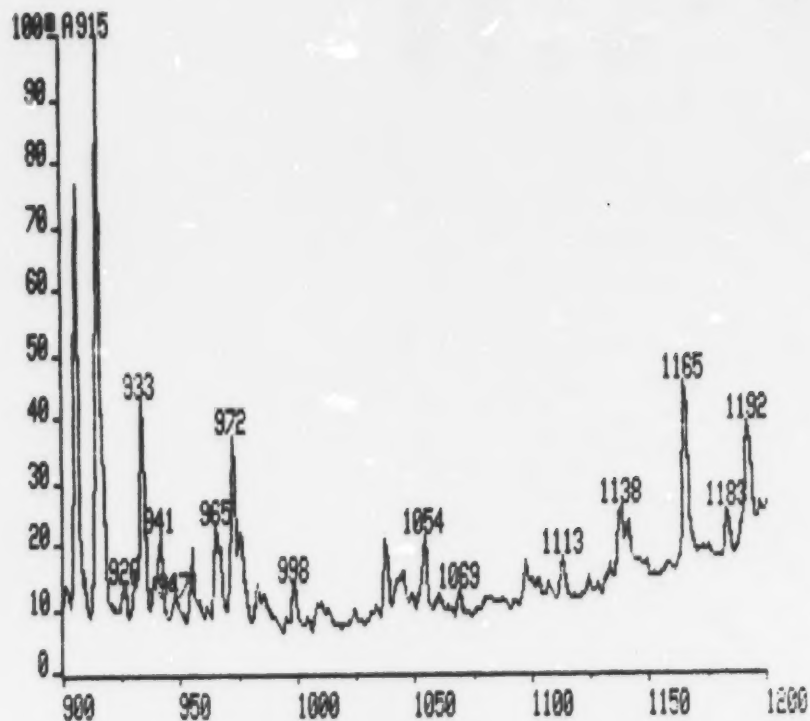


FIGURE 24

R90 #1-1900
A :ATIC

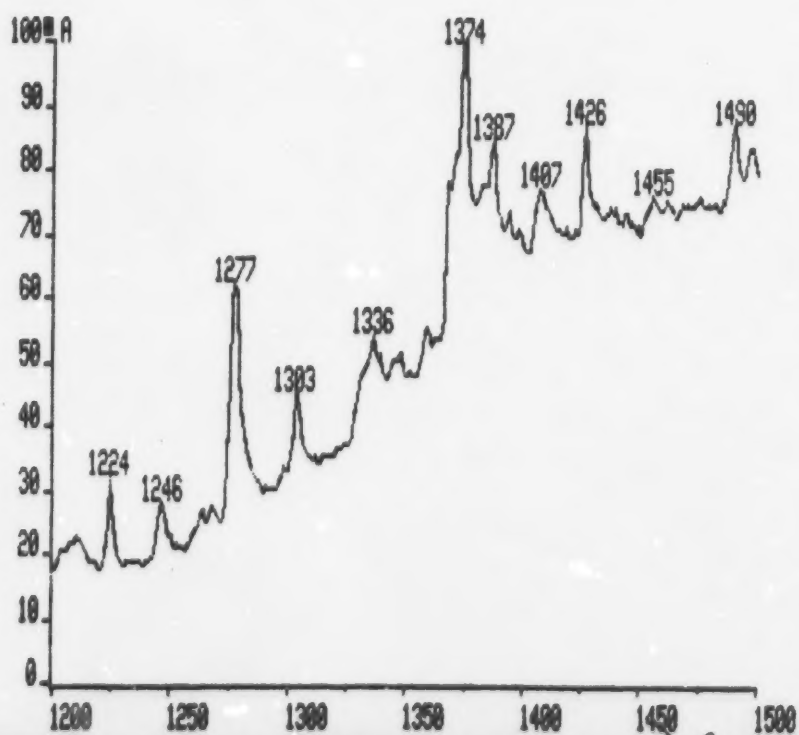
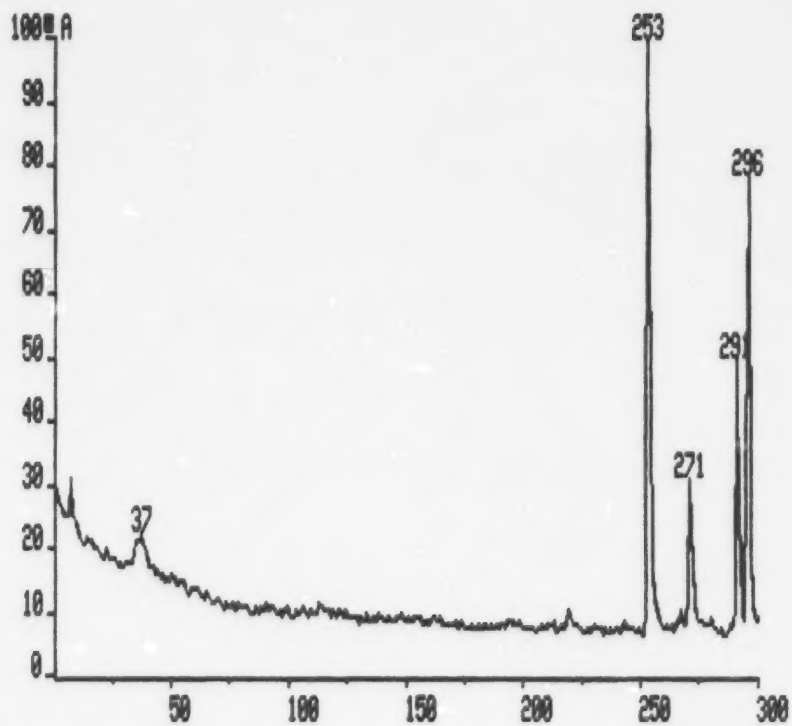


FIGURE 25

R91 #1-1700
A :ATIC



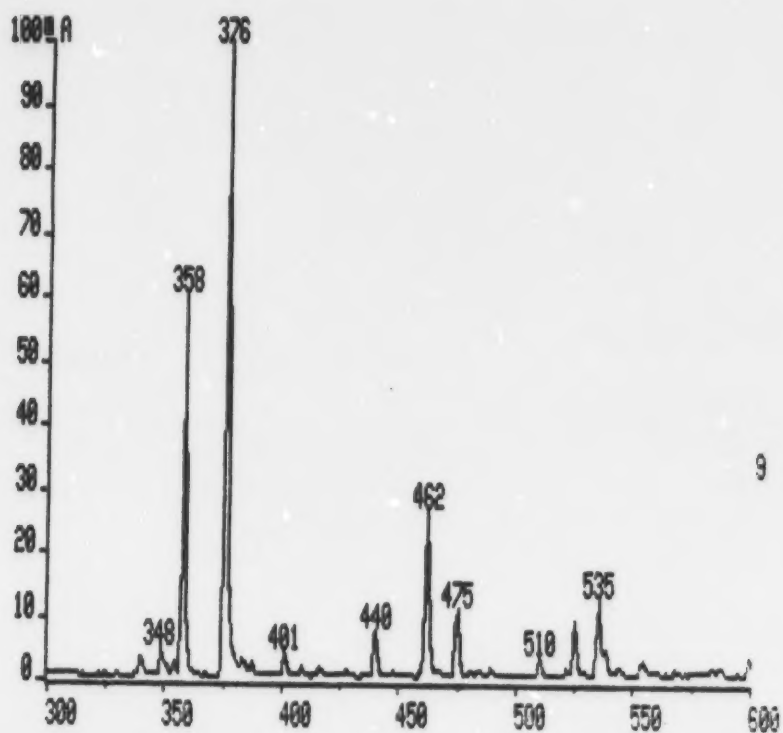
1.00
319

Ref:

Expt. No. Ph11

Co-Mo-S Catalyst

FIGURE 26

R91 #1-1700
A :ATIC1.00
2474

9

FIGURE 27

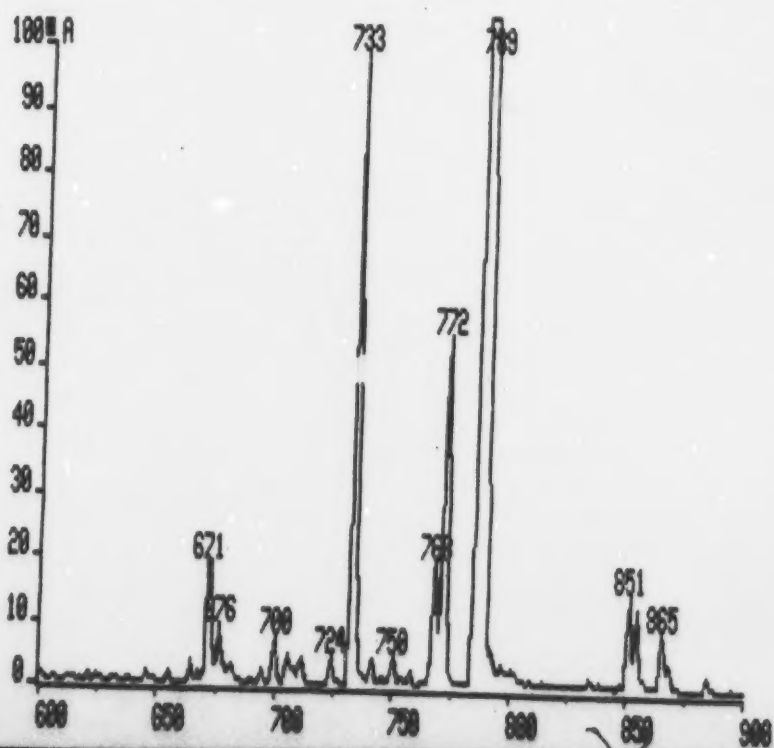
R91 #1-1700
A :ATIC1.00
5147

FIGURE 28

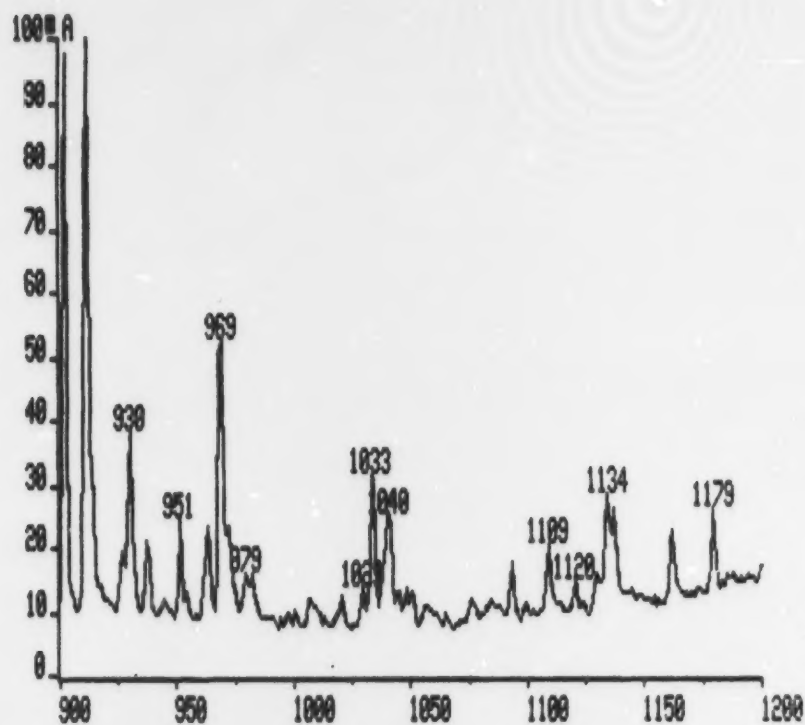
R91 #1-1700
A :ATIC1.00
326

FIGURE 29

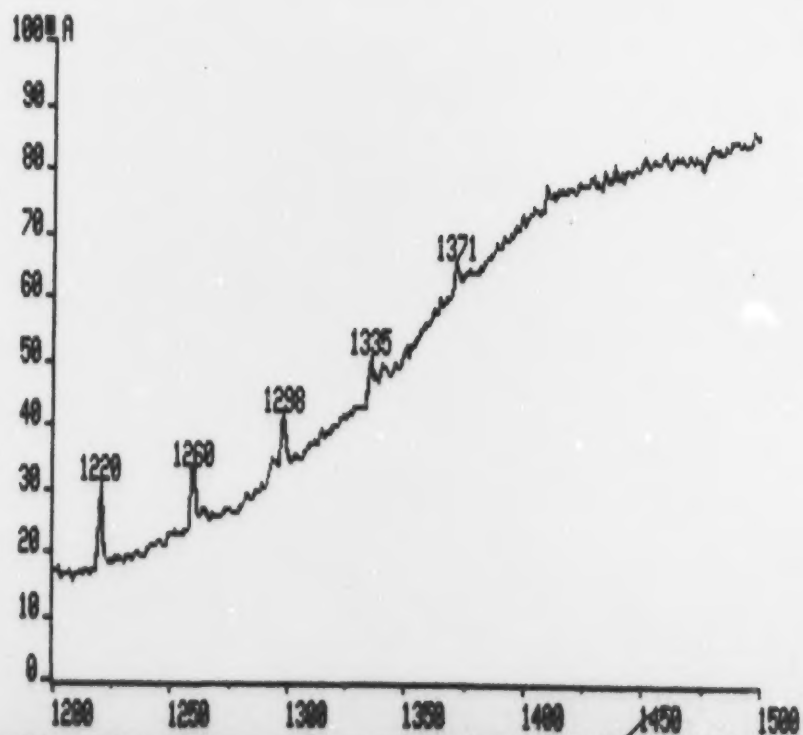
R91 #1-1700
A :ATIC1.00
326

TABLE 9

Qualitative Analysis of Liquid
Products from FHP of Phenanthrene

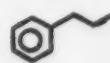
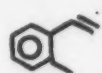
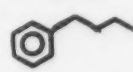
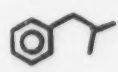
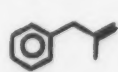
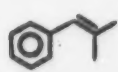
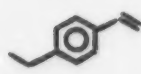
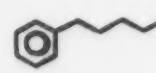
Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)	
34	0:46	91	91	C_7H_8	Toluene	
101	2:07	106	91	C_8H_{10}	o-Xylene	
107	2:14	106	91	C_8H_{10}	m-Xylene	
126	2:37	106	91	C_8H_{10}	p-Xylene	
179	3:41	120		C_9H_{12}	Propylbenzene	
250	5:07	118	117	C_9H_{10}	O-Methylstyrene	
269	5:30	134	91	$C_{10}H_{14}$	n-butylbenzene	
				or	isobutylbenzene	
				or	1,2,3,4-Tetramethylbenzene	
290	5:55	132	117	$C_{10}H_{12}$	3-phenyl-2-methyl-prop-1-ene	
295	6:02					
340	6:56	132	117	$C_{10}H_{12}$	1-phenyl-2-methyl-prop-1-ene	
349	7:05	132	117	$C_{10}H_{12}$	p-ethylstyrene	
355	7:14	148	91	$C_{11}H_{16}$	1-phenylpentane	

Table 9
Cont'd

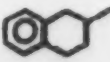
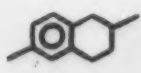
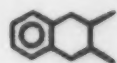
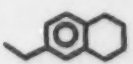
Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)	
358	7:17	132	104	$C_{10}H_{12}$	Tetrahydronaphtalene	
376	7:39	128	128	$C_{10}H_8$	naphtalene	
384	7:49	146	117	$C_{11}H_{14}$	1-ethylindan	
388	7:54	146	131	$C_{11}H_{14}$	mixture, naphtalene	
					1-methyltetrahydro- naphtalene	
402	8:10	146	104	$C_{11}H_{14}$	2-methyl-1,2,3,4- tetrahydronaphtalene	
410	8:20	146	131	$C_{11}H_{14}$	1-methyl-1,2,3,4- tetrahydronaphtalene	
441	8:58	146	131	$C_{11}H_{14}$	5-methyl-1,2,3,4- tetrahydronaphtalene	
464	9:25	142	142	$C_{11}H_{10}$	1-methylnaphtalene	
477	9:41	142	142	$C_{11}H_{10}$	1-methylnaphtalene	
482	9:47	160	118	$C_{12}H_{16}$	2,6-dimethyl-1,2,3,4- tetrahydronaphtalene	
491	9:58	160	104	$C_{12}H_{16}$	2,3-dimethyl-1,2,3,4- tetrahydronaphtalene	
512	10:23	160	13	$C_{12}H_{16}$	6-ethyl-1,2,3,4- tetrahydronaphtalene	
524	10:38				Isomer	

Table 9
Cont'd

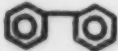
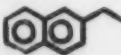
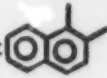
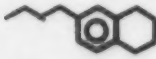
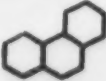
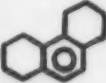
Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)	
527	10:41	154	154	$C_{12}H_{10}$	biphenyl	
538	10:55	156	141	$C_{12}H_{12}$	1-ethylnaphthalene or 2-ethylnaphthalene	 
540	10:57				Isomer	
546	11:04	156, 192	156	$C_{12}H_{12}$	mixture, main component 1,2-dimethylnaphthalene	
556	11:16				Isomer	
567	11:30	172	129	$C_{13}H_{16}$	trimethyl- dihydronaphthalene	
572	11:36	172	129		mixture trimethyldihydronaphthalene + other components	
589	11:56	188	92	$C_{14}H_{20}$	n-Butyltetralin (impure)	
591	11:59	192	67	$C_{14}H_{24}$	tetradeca- hydrophenanthrene	
617	12:30					
682	13:49	186	129	$C_{14}H_{18}$	octahydrophenanthrene	
686	13:53	186	171		Isomer	
730	14:47	186	171		Isomer	

Table 9
Cont'd

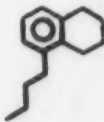
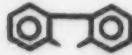
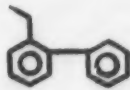
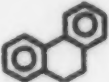
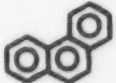
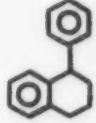
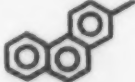
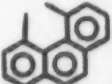
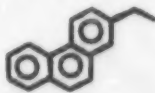
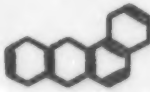
Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)
754	15:16	186	158		?
648	13:07	188	145	$C_{14}H_{20}$	
667	13:30	166	165	$C_{13}H_{10}$ Fluorene	
697	14:07	182	167	$C_{14}H_{14}$ 2-Ethyl-biphenyl	
703	14:14			Isomers	
709	14:21				
711	14:24				
714	14:27				
761	15:24				

Table 9
Cont'd

Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)	
736	14:54	180	180	$C_{14}H_{12}$	9,10-Dihydro-phenanthrene	
749	15:09	194	179	$C_{15}H_{14}$	2,3-Dimethyl-fluorene	
792	16:01	178	178	$C_{14}H_{10}$	phenanthrene	
851	17:13	208	179	$C_{16}H_{16}$	1-phenyl-1,2,3,4-tetrahydro-naphtalene	
855	17:17	192	192	$C_{15}H_{12}$	2-Methyl-phenanthrene	
906	18:19	206	191	$C_{16}H_{14}$	4,5-Dimethyl-phenanthrene	
					2-Ethyl-phenanthrene	
972	19:39	202	202	$C_{16}H_{10}^*$	Pyrene	
1054	21:18	234	234	$C_{18}H_{18}^*$	1,4,7,8,11,12-Hexahydro-benz(A)Anthracene	

* May be due to trace impurities in the reactants or trap used for other perylene reactions.

TABLE 10
Hydrogenation of Phenanthrene
Without Catalyst
(Recovery Studies)

Expt. No.	Residence Time (sec.)	Phenanthrene (in mg)	Catalyst/Ph* Ratio	Reaction Temp. (°C.)	pH ₂ (psig)	%Unreacted Phenanthrene
Ph1	1	7.77	Nil	764	1000	98.3
Ph2	1	5.50	Nil	550	1000	95.0
Ph3	2	7.44	Nil	750	1000	96.0
Ph4	2	8.00	Nil	650	1000	98.4

*Ph-Phenanthrene

TABLE II

Development of Base Conditions For
Hydrogenation of Phenanthrene Over Sulfided
Ni-W and Co-Mo Catalysts

Expt. No.	Residence Time (sec.)	Phenanthrene (in mg)	Catalyst/Ph Ratio (wt/wt)	Reaction Temp (° C.)	pH ₂ (psig)	% Total Yield
Ph5	1	5.00*	10.05	588	1000	75.8
Ph6	1	6.20*	3.80	800	1000	78.0
Ph7	2	6.44*	8.00	750	1000	72.0
Ph8	1	6.24*	6.40	800	1000	67.4
Ph9	1	4.80**	5.20	800	1000	70.8
Ph10	2	10.04**	9.80	750	1000	76.2

Ph-Phenanthrene

*—Ni-W Sulfided Catalyst

**—Co-Mo Sulfided Catalyst

TABLE 12
Reaction Conditions for the Flash Hydropyrolysis
Of Phenanthrene Over Ni-W-S Alumina
And Co-Mo-S/Alumina

Expt. No.	Residence Time (sec.)	Catalyst Used	Phenanthrene (in mg)	Catalyst/Ph Ratio (wt/wt)	Reaction Temp. (°C.)	PH ₂ (psig)
Ph11	2	Ni-W-S	6.20	10.00	750	1000
Ph12	2	Co-Mo-S	6.84	10.42	588	1000

Ph-Phenanthrene

TABLE 13
Major Product Yields in
FHP of Phenanthrene
% Carbon by Weight

Products		Experiment Number	
		Ph11	Ph12
C_1H_4	Methane	10.50	8.66
C_2H_6	Ethane	9.80	8.46
C_3H_8	Propane	13.42	12.47
C_4H_{10}	Butane	2.80	4.24
C_5H_{10}	Pentane	<0.30	0.50
C_6H_6	Benzene derivative*	0.80	0.77
C_7H_8	Toluene	0.90	0.55
$C_{10}H_{12}$	Tetralin	2.50	1.50
$C_{10}H_8$	Naphthalene	2.80	2.25
	Naphthalene derivatives	6.80	6.66
$C_{12}H_{10}$	Biphenyl	1.60	1.33
$C_{14}H_{12}$	Dihydrophenanthrene	5.80	8.86
$C_{14}H_{18}$	Octahydrophenanthrene	1.5)	2.55
$C_{14}H_{14}$	Tetrahydrophenanthrene	4.80	3.30
$C_{14}H_{10}$	Phenanthrene	<u>28.80</u>	<u>32.38</u>
	TOTAL	93.12	94.4°

*Calculated using Benzene FID response

TABLE 14
Effect of Catalyst to Phenanthrene Ratio on
The Hydrogenation of Phenanthrene Over
Sulfided Ni-W catalyst

Expt. No.	Residence Time (sec.)	Phenanthrene (1n mg)	Catalyst/Ph* Ratio (wt/wt)	Reaction Temp (°C.)	PH ₂ (psig)	% Total Yield
Ph13	2	3.20	19.33	732	1000	74.8
Ph14	2	3.00	5.40	730	1000	71.2
Ph15	2	3.40	2.00	735	1000	65.4
Ph16	2	3.00	0.50	750	1000	43.8

Ph* = Phenanthrene

TABLE 15
Effect of Hydrogen Concentration
On the Hydrogenation of Phenanthrene

Expt. No.	Residence Time (sec.)	Phenanthrene (in mg)	Catalyst/Ph* Ratio (wt/wt)	Reaction Temp (°C.)	PH ₂ (psig)	% Total Yield
Ph17	2	3.2	20.00	750	500	65.8
Ph18	2	3.2	20.00	740	200	38.2

*Ph=Phenanthrene

V.3 Hydrogenation of Chrysene

The results of hydrogenation of chrysene over sulfided Ni-W and Co-Mo catalysts are presented in table 16 to 20.

The condensed chromatogram of a typical liquid and gaseous products are given in figure 27A and 27B, respectively. For quantitative analysis, chromatographic conditions were modified so as to allow the separation of GC peaks for low and high boiling components.

A number of difficulties were encountered due to the requirement of heating the tube joining the residence zone up to the collecting trap.

The capillary chromatogram of the FHP products formed between naphthalene and chrysene employing Ni-W catalyst is given in figure 28. The identified products are given in table 19. The mass spectrum of the base peaks are given in Appendix IV.

Figure 27

Chromatogram of Liquid and Gaseous
FHP Products of Chrysene using Ni-W
Sulphided Catalyst

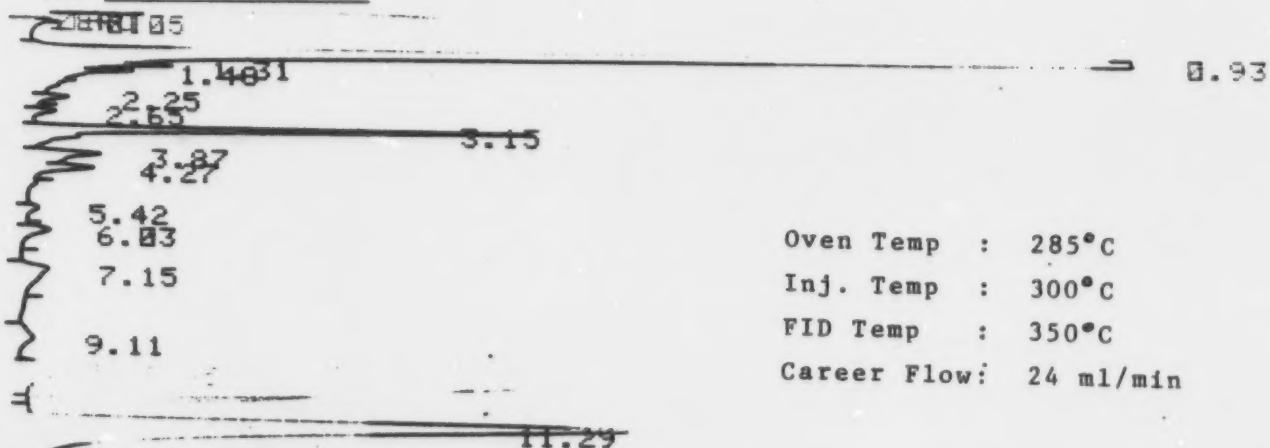
76

16.53
 17.71

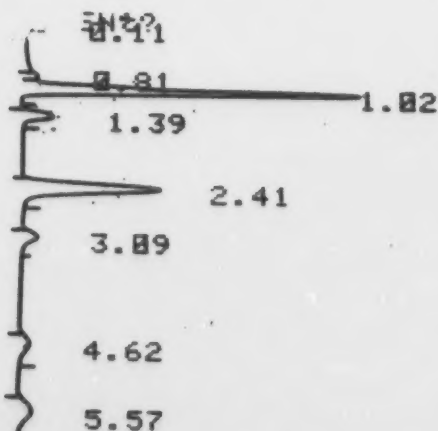
STOP
 5830A

RTIME	AREA	AR%
0.06	666	0.09
0.94	159600	22.76
3.20	721	0.10
7.33	3556	0.51
9.90	10860	1.55
11.25	524500	74.79
16.53	1375	0.20

#94 Chrysene Run

(A) Liquid Products

Oven Temp : 285°C
 Inj. Temp : 300°C
 FID Temp : 350°C
 Carrier Flow: 24 ml/min

(B) Gaseous Products

1. Methane
2. Ethane
3. Propane
5. Isobutane
6. Pentane

TABLE 16
Hydrogenation of Chrysene
Without Catalyst
(Recovery Studies)

Expt. No.	Residence Time (sec.)	Chrysene (in mg)	Catalyst/Ch* Ratio	Reaction Temp. (°C.)	pH ₂ (psig)	% Unreacted Chrysene
Ch 1	1	6.81	N:1	800	1000	103.2
Ch 2	1	7.24	N:1	840	1000	93.8
Ch 3	1	8.11	N:1	850	1000	105.0
Ch 4	2	7.60	N:1	875	1000	95.6

* Ch = Chrysene

TABLE 17
Development of Base Conditions For
Hydrogenation of Chrysene over Sulfided
Ni-W and Co-Mo Catalysts

Expt. No.	Residence Time (sec.)	Chrysene (in mg)	Catalyst/Ch Ratio (wt/wt)	Reaction Temp. (°C.)	pH ₂ (psig)	% Total Yield
Ch 1	1	8.38*	10.80	913	1000	78.88
Ch 2	1	5.75*	5.72	755	1000	82.40
Ch 3	2	6.88**	10.32	741	1000	76.80
Ch 4	2	4.85**	6.52	850	1000	79.60

Ch = Chrysene

* = Ni-W Sulfided Catalyst

** = Co-Mo Sulfided Catalyst

TABLE 18
Reaction Conditions for the Flash
Hydropyrolysis of Chrysene over Ni-W-S Alumina
And Co-Mo-S/Alumina

Expt. No.	Residence Time (sec.)	Catalyst Used	Chrysene (in mg)	Catalyst/Ch Ratio (wt/wt)	Reaction Temp. (°C.)	pH ₂ (psig)
Ch 5	2	Ni-W-S	8.57	10.57	850	1000
Ch 6	2	Co-Mo-S	6.92	8.62	780	1000

Ch = Chrysene

TABLE 19

Major Product Yields in FHP of
Chrysene: % Carbon By Weight

Products	Experiment Number	
	Ch 5	Ch 6
Methane	14.8	16.8
Ethane	4.4	6.5
Propane	10.0	8.5
Isobutane	4.0	3.8
Butane	4.0	5.4
Pentane	4.8	3.5
Naphthalene	3.0	4.5
Naphthalene derivative	?	?
9,10 dihydrophenanthrene	1.4	1.8
Phenanthrene	15.7	16.8
Unidentifiable	?	?
Dihydrochrysene	3.6	2.8
Chrysene	21.8	23.8

GC/MS Conditions For Figure 28

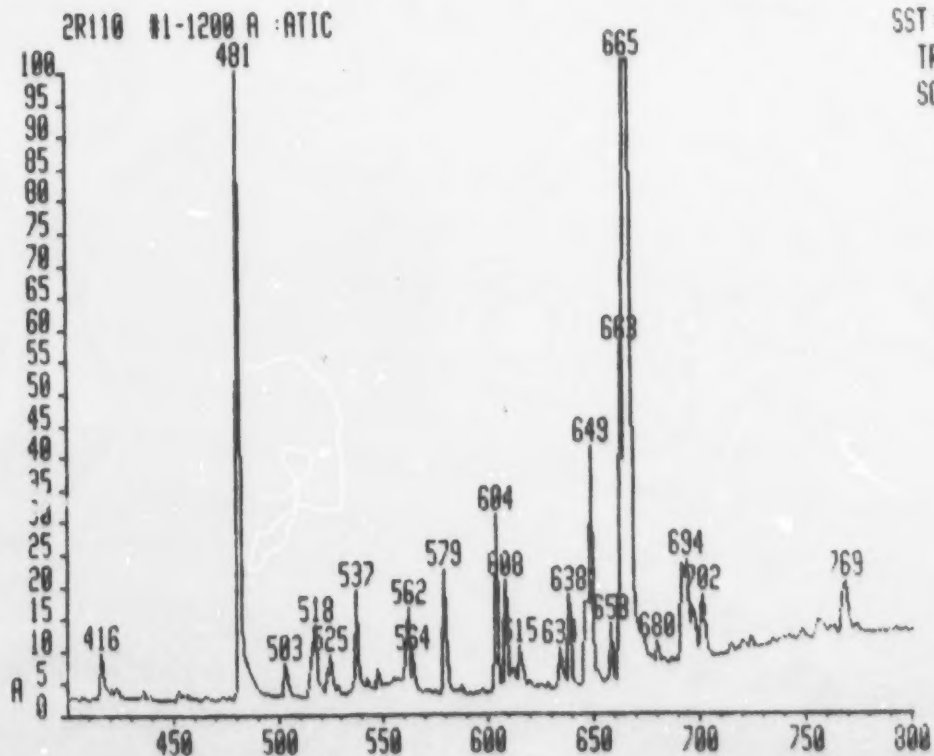
Instrument : Hewlett-Packard 5790
 Column : 30m x 0.25 DBS fused silica capillary
 Flow Rate : 1 ml/min He
 Injection Temp. : On column
 Program Condition: 20 /min; final temp.: 325° Celcius
 Injection Volume : 1 μ l

MS Conditions (See Appendix IV)

Multiplier Voltage: 1600 e.m.v.
 Scan Speed : 1 scan/second
 Scan Range : 50-350 mass units

FIGURE 28

Capillary Chromatogram of the FHP Products
 Of Chrysene over Ni-W Catalyst



SST: 2254
 TRACE A
 SCAN 481

TABLE 20

Qualitative Analysis of Liquid Products
From Naphthalene to Chrysene in the FHP
of Chrysene

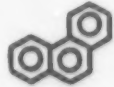
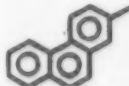
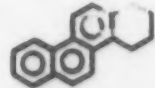
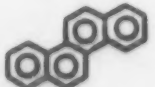
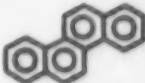
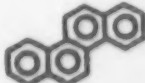
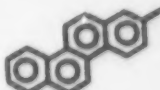
Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)	
260	5:19	128	128	$C_{10}H_8$	Naphtalene	
481	9:46	178	178	$C_{14}H_{10}$	Phenanthrene	
503	10:13	204	203	$C_{16}H_{12}$	Dihdropyrene	
					Dihydrofluorene	
518	10:31	192	192	$C_{15}H_{12}$	2-Methylphenanthrene	
537	10:54	204	204	$C_{16}H_{12}$	Dihdropyrene	
					Dihydrofluorene	
564	11:27	202	202	$C_{16}H_{10}$	Pyrene	
608	12:20	216	215	$C_{17}H_{12}$	Methylpyrene	
634	12:51	230	230	$C_{18}H_{14}$	dihydrochrysene	
649	13:09	228	228	$C_{18}H_{12}$	chrysene	

Table 20
Con't

Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)	
663	13:26	228	228	$C_{18}H_{12}$	Chrysene	
666	13:30	228	228	$C_{18}H_{12}$	Chrysene	
694	14:04	242	242	$C_{19}H_{14}$	Methylchrysene	
769	15:34	252	252	$C_{20}H_{12}$	Perylene*	

* Number of Perylene runs were taken using the same reactor and trap. The trace quantities observed here may be due to contamination. In a number of other FHP runs analyzed by GC, there was no evidence of the formation of high molecular weight species.

V.4 Hydrogenation of Perylene

In the initial study, a number of perylene runs were taken for recovery studies using coiled liquid nitrogen traps. No catalyst was used in the recovery studies. The amount of perylene recovered varied to 70 percent of the perylene weight in the reactor temperature range 600° to 700°C. Possible reason for incomplete recovery was considered. Condensation was occurring ahead of the trap. In later runs, the temperature was increased to 900°C. and the temperature between reactor and trap were increased to 500°C. Satisfactory recoveries were then observed. Perylene was found completely soluble in carbon disulfide solvent.

Transfer line heating tape covered a very small length (about six inches) between the reactor and the trap and the temperature of 400° to 500°C. was maintained. The catalytic runs were taken with a new batch of sulfided Ni-W catalysts. The conversion was calculated using unreacted perylene. Subsequent analysis of the trapped products indicated no significant peaks other than perylene. It was later found that the heating tapes were not working during these experiments and condensation occurred ahead of the trap resulting in erroneous results. In the majority of the experimental runs, no significant liquid and gaseous products were observed. Various attempts in dozens of experiments employing different heating rates, catalyst to reactant ratio failed to yield

products. It was discovered later that Perylene sublimes at 350 C. As a result, it escaped the catalyst contact and only partial products were formed.

The formation of methane, ethane, and propane was observed when the catalyst to the perylene ratio was increased to 50:1 and the gases analyzed under high autonuation. This is shown in figure 30. The liquid products could not be observed in significant amounts for quantitative analysis. The capillary chromatogram of one of the experiments is also shown in figure 30. The identification of some of the products detected are given in table 22.

FIGURE 30

91

The Gaseous and Liquid Products Detected
In the FHP of Perylene Using Sulfided
Ni-W catalyst (catalyst/Perylene=50)

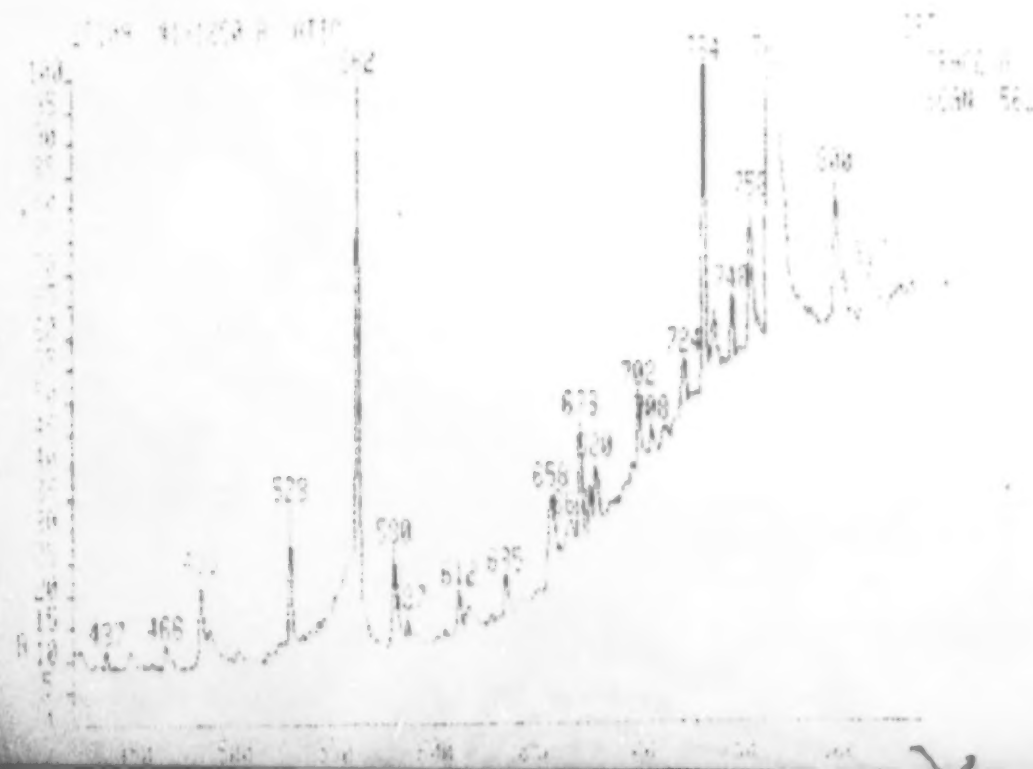
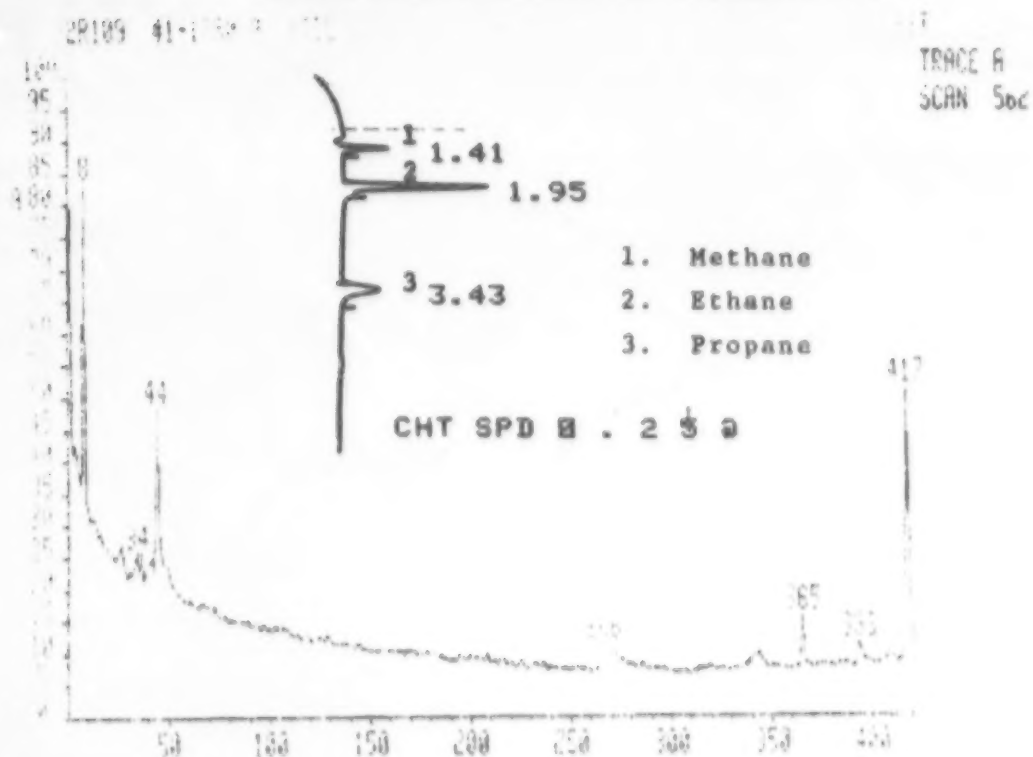


TABLE 22

The Detected Products* in FHP
of Perylene by GC-MS

Spectrum Number	Retention Time(min)	Molecular Ion m/e	Base Peak	Formula	Identification (tentative)	
44	0:58	92	91	C_7H_8	Toluene	
266	5:27	128	128	$C_{10}H_8$	Naphtalene	
365	7:26	106	106	C_8H_{10}	Xylenes	
483	9:49	178	178	$C_{14}H_{10}$	Phenanthrene	
580	11:46	202	202	$C_{16}H_{10}$	Pyrene	
667	13:31	228	228	$C_{18}H_{12}$	Chrysene	
734	14:52	258	258	$C_{20}H_{18}$	Hexahydروperylene	
769	15:34	252	252	$C_{20}H_{12}$	Perylene	
800	16:11	266	266	$C_{21}H_{14}$	Methylperylene	

* Perylene sublimes at 350° C. Consequently, the reaction is not significant.

TABLE 21

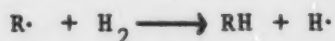
Recovery Studies of Perylene for the
Development of Base Conditions (without Catalyst)

Reactant	Residence Time (sec)	Reaction Temp (°C)	PH ₂ (psig)	% Recovery
Perylene	1	600	500	60.5
	1	700	500	75.0
	1	800	500	78.5
	1	910	500	95.5
	1	920	500	96.8
	2	900	500	102.8
	2	900	500	98.6

VI DISCUSSION

The theoretical aspect of the hydropyrolysis of hydrocarbons has not advanced as much as the technological possibilities. The reason for this is that this process is one of the most complicated reactions of hydrocarbon chemistry. The mechanism of the overall reaction includes consecutive and parallel partial reactions. The appearing intermediate compounds, most of them radicals, are short-lived and experimentally difficult to detect.

The reactions taking place during hydropyrolysis are probably dominated by free radical chemistry. Catalytic effects are extensive and are required for the hydrogenation reactions to proceed. Cracking reactions are probably initiated thermally by the opening of the polynuclear aromatic (PNA) hydrocarbon ring structure and formation of free radicals. Subsequent reaction of the free radicals and hydrogen may follow in the chain propagation process. Shabtai, et al (23) have postulated the reaction



as a significant reaction in the hydropyrolysis of n-decane. In the high pressure hydrogen and favourable activation energy, many free radicals present would undergo the above reaction. This reaction is, therefore, of considerable significance. First, free radicals present have an early opportunity to become saturated before other bimolecular reactions can occur. Such processes as polymerization or condensations leading to high molecular weight formation

or coke are thus inhibited. As shown in the result section, such reactions are indeed not taking place. The work on the FHP of model compounds presented in this investigation indicate that any products of molecular weight higher than reactants are not formed. Second, by using short residence time and rapid quenching of products, the reaction is terminated preventing dehydrogenation, repolymerization, carbonization and decomposition. The effects of catalyst and hydrogen on the FHP of model compounds studied are obvious in the results of this investigation.

Third, the production of a free hydrogen atom may have some interesting implications. The hydrogen atom may abstract a hydrogen atom from a saturated carbon. The resultant free radical may undergo β -elimination to produce another hydrogen atom and an olefin or may undergo β -scission to crack the molecule forming an olefin and a hydrocarbon free radical. Also, the hydrogen atom may attack the unsaturated carbon such as aromatic ring and the resulting dienyl radical formed may undergo ring opening with consequent destruction of aromatic ring or become saturated by a hydrogen from H_2 , thus reducing the resonance stabilization of the ring and making it susceptible to further reaction sequence.

As a result of the concurrent, consecutive reactions, and the effect that the catalyst has, the nature of the reactions of the FHP processes are too complex.

The complexity of the products formed is evident upon inspection of the chromatograms of liquid FHP products of Naphthalene, Phenanthrene and Chrysene. The chromatogram using capillary column are given in the result section and the corresponding mass spectrum of the products are given in the appendices. These GC/MS spectrum were used for the identification of the products.

The yields are similar for both catalysts, Ni-W and Co-Mo. The average conversion to gaseous and liquid product for Naphthalene, Phenanthrene and Chrysene were found to be 60%, 73%, and 80% respectively. Due to hydrogen consumption the gaseous products C_1-C_5 are certainly not so much desirable and these are found to be in significant amounts.

As pointed out in section III of this manuscript, the historical development of catalytic hydrogenation of polynuclear aromatic compounds has been discussed in detail in a review by Smith (10). Active catalysts include the Group VIII transition metals in various reduced forms, oxides and sulfides of molybdenum and tungsten and copper. Several observations deserve comment and are common to all the catalysts studied. First, the hydrogenation reactions generally take place in a step-wise fashion so as to maintain a maximum resonance in any intermediate product even if this involves a shift in unsaturation from one ring to another.

A second observation is that the ease of hydrogenation tends to increase with increasing the size of the molecule. For example, the relative rates of Benzene, Naphthalene and Anthracene over sulfided tungsten catalyst were reported to be 100, 2300 and 6187 respectively. The observation that the yield of Naphthalene hydrogenation is low under similar reaction conditions supports the view that the ease of hydrogenation increases with increasing the size of the hydrocarbon molecule.

An investigation of the thermal hydrogenolysis of Phenanthrene and Anthracene was reported by Penniger and Slotboom (20). They found that both tricyclics are cracked mainly by a stepwise hydrogenation, ring opening and side chain cracking.

Cracking within the side chain was extensive in contrast to the dealkylation of side chains normally observed over acidic catalysts. The main hydrogenation products were 1,2,3,4-tetrahydrophenanthrene and 9,10-dihydrophenanthrene. At a higher temperature ($>500^{\circ}\text{C}$) cracking took place. The main products formed were 2-ethylnaphthalene, ethylbiphenyl, 2-methylnaphthalene, naphthalene biphenyl and 2-ethylbiphenyl. The presence of ethylbiphenyl and biphenyl suggests a mechanism involving the ring opening of dihydrophenanthrene between the 10 and 11 carbon atoms. (see Fig. 8). This is an evidence of hydrocracking the phenanthrene molecule at the central ring. The major products though, which

are the substituted naphthalenes, are produced through a hydrogenation and cleavage of the terminal rings (see Fig. 7). It is known that biphenyl itself is almost inert to catalytic cracking over an acidic silica-alumina catalyst. A kind of biphenyl-like bond, between the 12 and 13 carbon atoms, exists in the phenanthrene molecule. Gardner and Hutchinson (24) found that low acidity metal oxide catalysts were successful in hydrocracking biphenyl.

Figure 7

Thermal Hydrogenolysis of Tetrahydro Phenanthrene, Penninger and Slotboom (20)

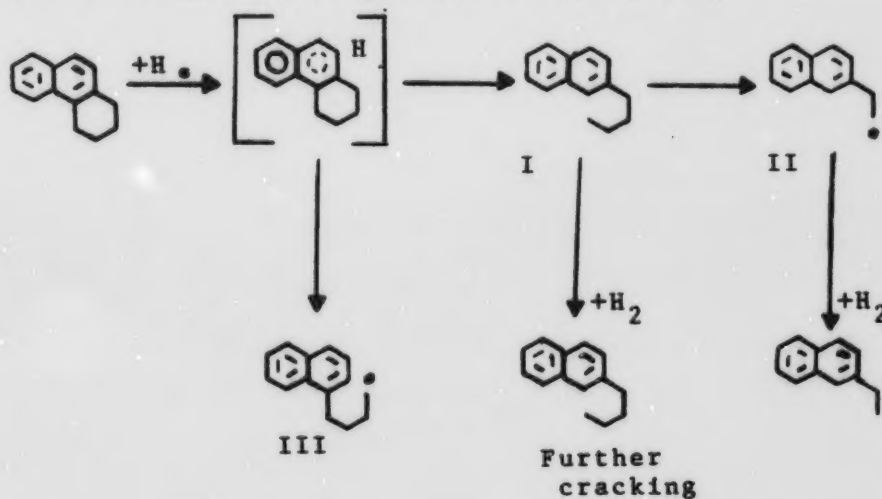
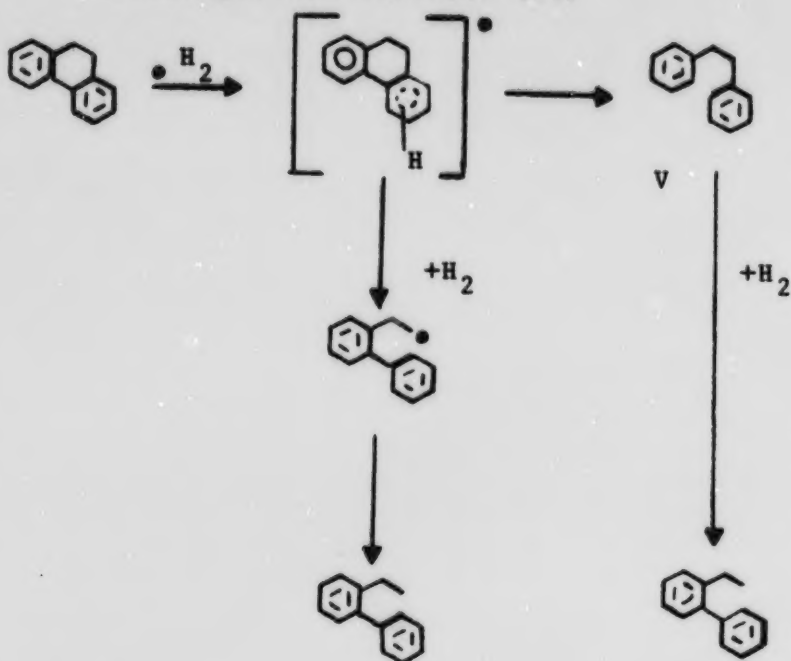


Figure 8

Thermal Hydrogenolysis
of Dihydrophenanthrene
Penninger and Slotboom (20)



Skowronski and Recht (21) hydrocracked phenanthrene in the presence of a 50/50 mixture of $\text{MOH}/\text{M}_2\text{CO}_3$ ($\text{M}=\text{Li}, \text{Na}, \text{K}$) in a batch autoclave at 475°C and 3000 psi. While considerable hydrogenation and ring opening reactions were observed, the conversion to cracked product was low. The product distribution was similar to the thermal data of Penninger and Slotboom (20) as depicted in Figure 8. The cracked products were mostly alkynaphthalenes. Substantial amounts of 2-ethylbiphenyl and smaller amounts of diphenylethane were also present.

In our study, the observed hydrogenation products are: Dihydro-, Tetrahydro-, Octahydro-, and Perhydro-phenanthrene. The present work, therefore, supports the stepwise succe-

ssive hydrogenation steps on the terminal and inner rings.

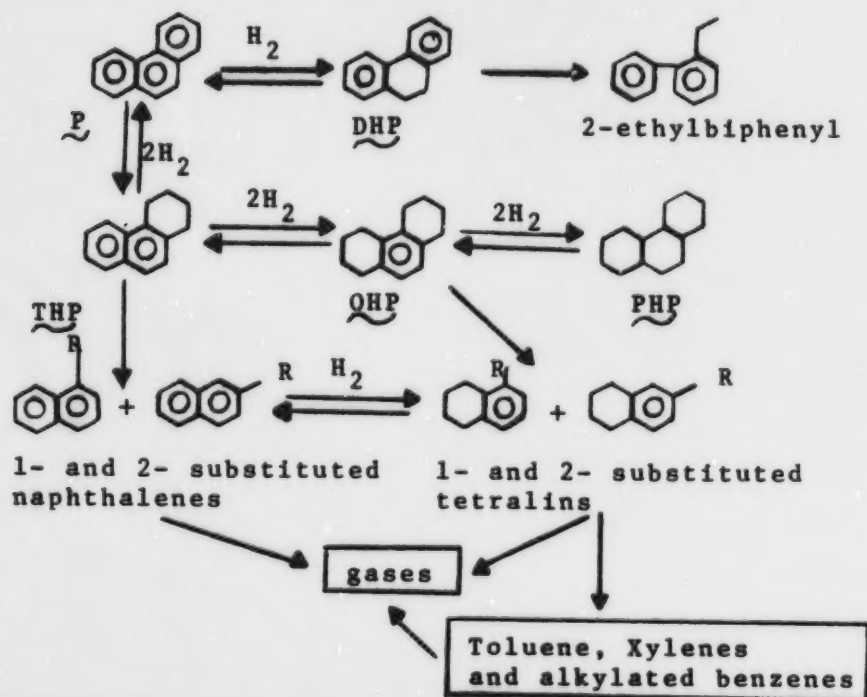
The absence of large branched paraffins indicates that ring opening of perhydrophenanthrene does not take place under the applied experimental conditions. The presence of substantial quantities of naphthalene, 1- and 2- substituted naphthalenes, tetralin and substituted tetralins as also toluene and xylenes serves as evidence that the major reaction path follows the partial hydrogenation of end rings, ring opening and side chain cracking, as is also observed by Penninger and Slotboom (20). The large amounts of gases (methane, ethane, propane, butane) which are produced, substantiates the assumption of predominance of the terminal ring opening and dealkylation mechanism. Lighter than butane gases are formed probably by a side chain cracking of n-butylnaphthalene and n-butyltetralin or by secondary reactions of n-butane (see the figure in the suggested mechanism). Other PNA's would follow the same reaction sequence.

We do find minor amounts of ethylbiphenyl and biphenyl indicative of central ring opening. The presence of some substituted naphthalenes and tetralins in other than the 1 or 2 position indicate also that secondary alkylation reactions take place. The trace quantities of higher polyaromatics detected, such as fluorene, pyrene, chrysene and/or Benz(A)Anthracene are impurities in the trap from previous experiments using these as starting materials.

As a secondary reaction of insignificant importance is also observed alkylation of phenanthrene at 2 and 4,5 positions.

Figure

Proposed Mechanism for the Formation of Products in FHP of Phenanthrene



- | | |
|--------------|---------------------------|
| P | = Phenanthrene |
| DHP | = Dihydrophenanthrene |
| THP | = Tetrahydrophenanthrene |
| OHP | = Octahydrophenanthrene |
| PHP | = Perhydrophenanthrene |
| R | = Butyl, Ethyl and Methyl |

VII Rationale for Future Work

In this study, the extent to which naphthalene, phenanthrene, and chrysene have been found to be hydrogenated in catalytic FHP process is of considerable interest. The remarkable feature of Ni-W, and Co-Mo have been noted in terms of their ability to remain active. Without the catalyst, the hydrogenation reactions did not proceed under the experimental conditions employed, ie temperature, pressure etc. As is known, partially hydrogenated derivatives of phenanthrene are very active hydrogen donors in the coal liquefaction processes.

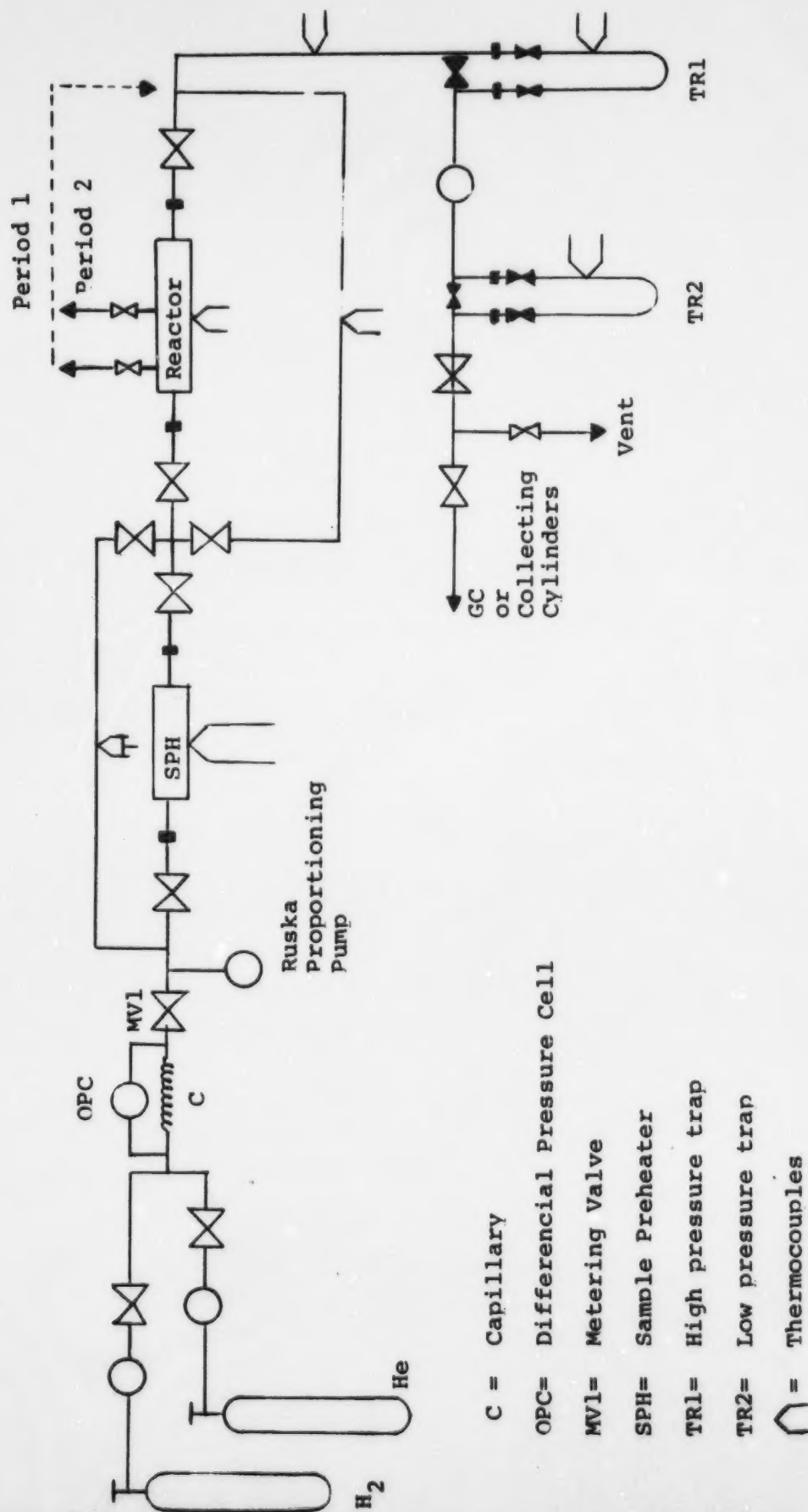
In addition, conversion to lower molecular weight species is desirable. Both the catalysts employed in this study have accomplished this. However, the formation of gases, viz, methane, ethane, propane is not so much desirable at the expense of BTX liquids or the liquids of naphtha range. The main drawback of gaseous products is the high hydrogen consumption and the non-liquid type fuel currently is not in short supply. In view of the promising conversion observed in the catalytic FHP process, this study should be continued. The objective of this study would be a search of catalyst which allows the extent of conversion observed in this study or better without the formation of gaseous products.

Zeolites were first introduced into commercial catalysis in the early 1960's and today, virtually all catalytic cracking catalysts contain zeolites. It is essential that potential zeolite catalyst should possess, open pore structure. Synthetic faujasite-type X and Zeolite Y have been very successful and these should be used in the proposed studies. Molten ZnCl_2 catalysts should also be studied.

Finally, other catalysts which are cheap and disposable must be tried. One such catalyst is iron pyrite. Because of the implicit advantages, a flow reactor such as shown in figure 31 must be used so that the reaction product can be studied at different yield periods, larger quantities of feed stock and a more practical approach towards process development.

FIGURE 31

Flow Diagram of Flow Reactor



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APPENDICES

APPENDIX I

Composition of Polynuclear Aromatic
Hydrocarbons (PNA's) in Flash
Hydropyrolysis Product of Lignite Coal
(Reference 3)

TABLE 1

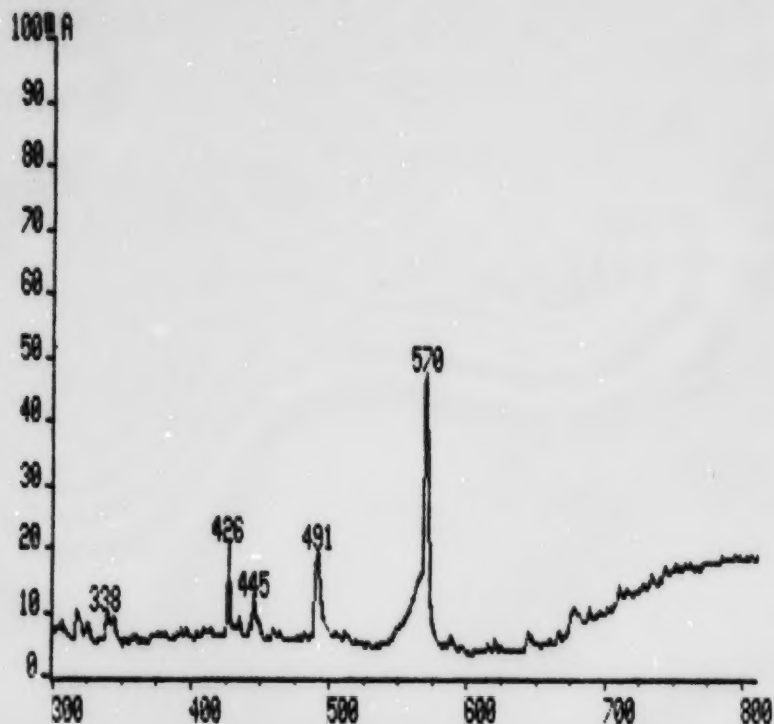
Composition of Polynuclear Aromatic
Compounds (PNA's) in FHP Products of
Lignite Coal (Reference 3)

Serial Number	Tentatively Identified PNA's	Percent by Weight
1	Naphthalene	47.63
2	2-Methyl Naphthalene	5.57
3	1-Methyl Naphthalene + Azulene	2.12
4	Biphenyl	4.97
5	2,6-Dimethyl Naphthalene	0.16
6	1,3 and/or 1,6-Dimethyl Naphthalene	0.42
7	1,5 and/or 2,3-Dimethyl Naphthalene	0.15
8	1,2-Dimethyl Naphthalene and/or Acenaphthylene	0.14
9	Acenaphthene	1.10
10	Fluorene	8.39
11	9,10-Dihydroanthracene	0.52
12	9-Methyl Fluorene	0.74
13	1-Methyl Fluorene	0.50
14	Phenanthrene	12.89
15	Anthracene	0.97
16	2-Methyl Anthracene	0.14
17	1-Methyl Phenanthrene	0.37
18	Fluoranthene	1.98
19	Pyrene	4.41
20	1,2-Benzofluorene	0.91
21	2,3-Benzofluorene	1.02
22	1-Methyl Pyrene	0.08
23	1,2-Benzanthracene	0.53
24	Chrysene	1.01
25	7,12-Dimethyl-1,2-Benzanthracene	0.15
26	1,2-Benzopyrene (BaP)	0.98
27	Perylene	0.36
28	3-Methyl Cholanthrene	0.15
29	O-phenylene pyrene	0.55
30	Picene	0.04
31	1,12-Benzoperylene	0.78
32	Anthanthrene	0.27
TOTAL		100.00

APPENDIX II

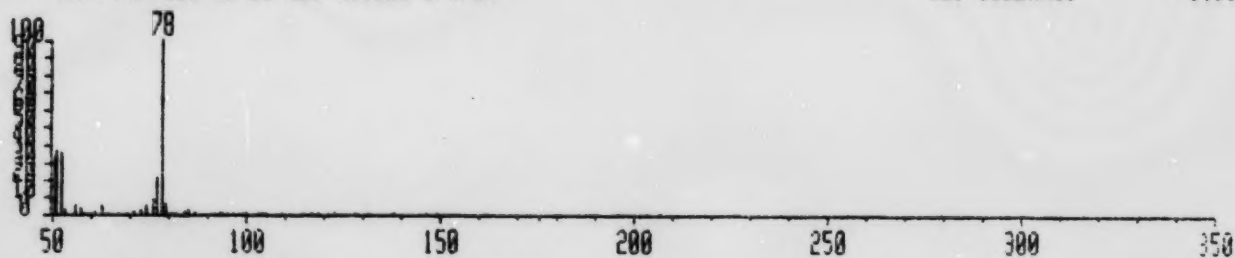
Mass spectrum of FHP Products
Of Napththalene, ref: table 4

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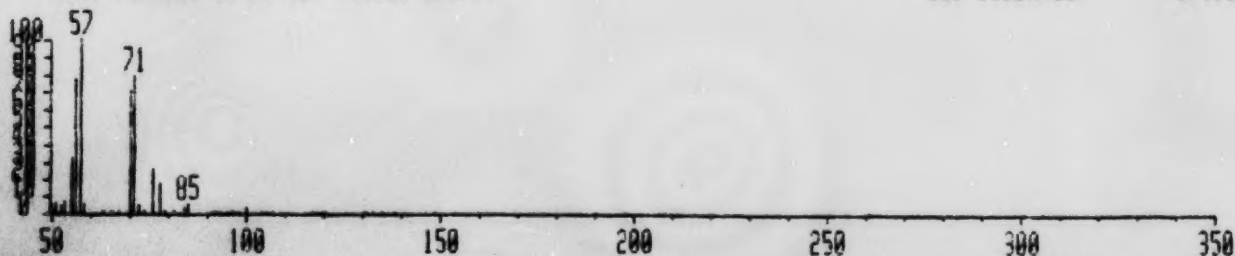


1.00
1007

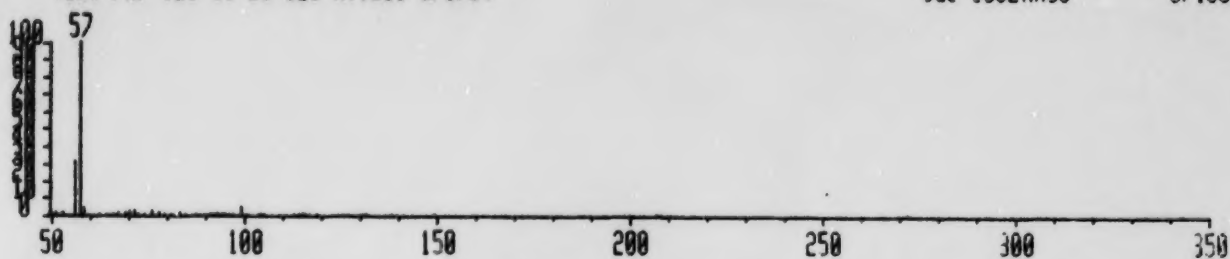
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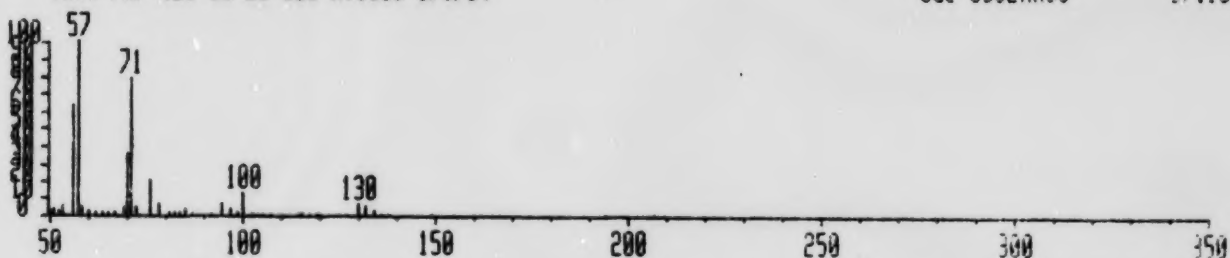
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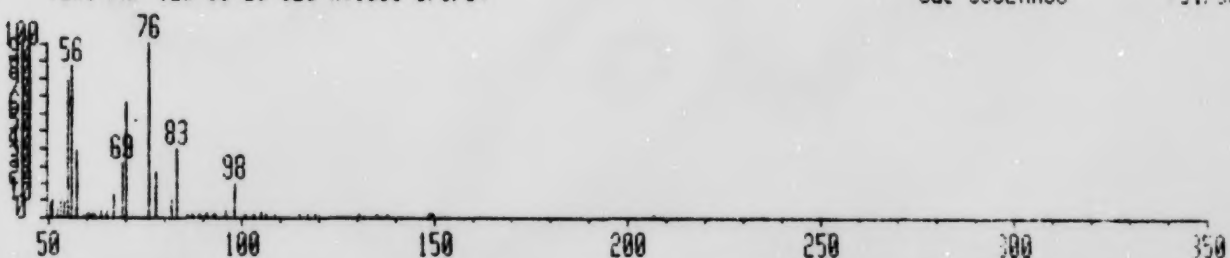
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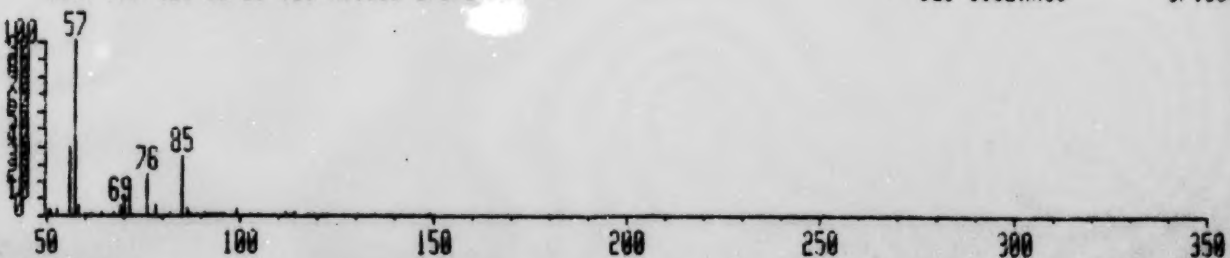
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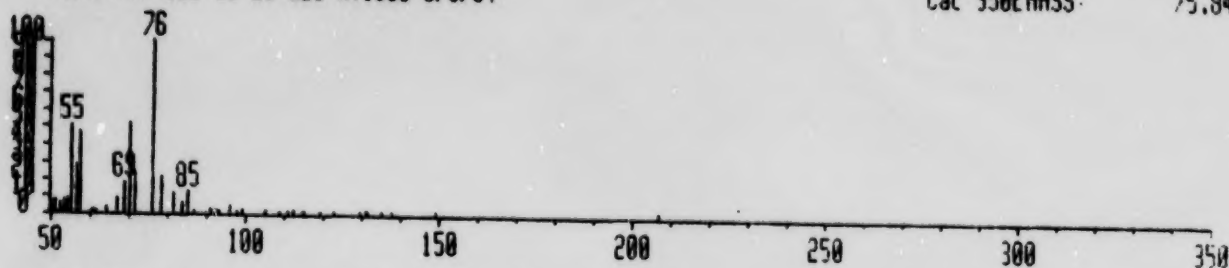
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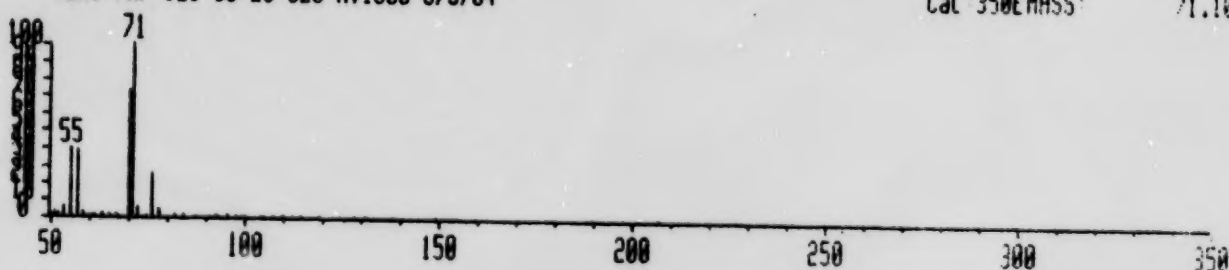
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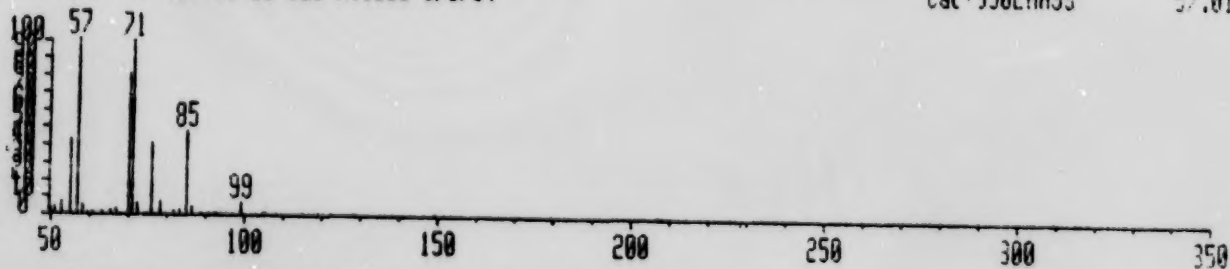
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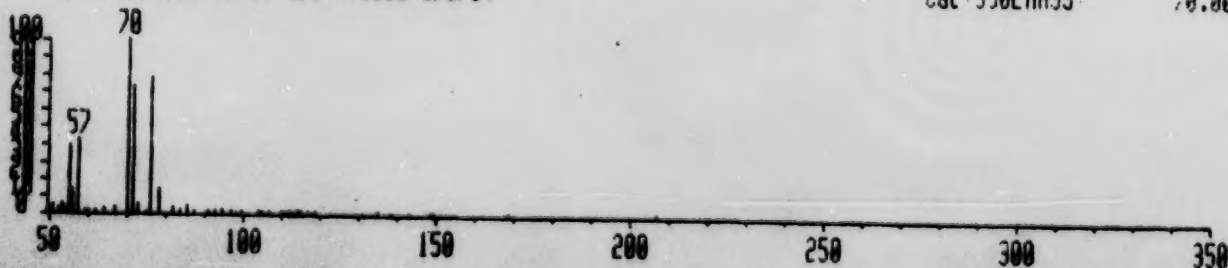
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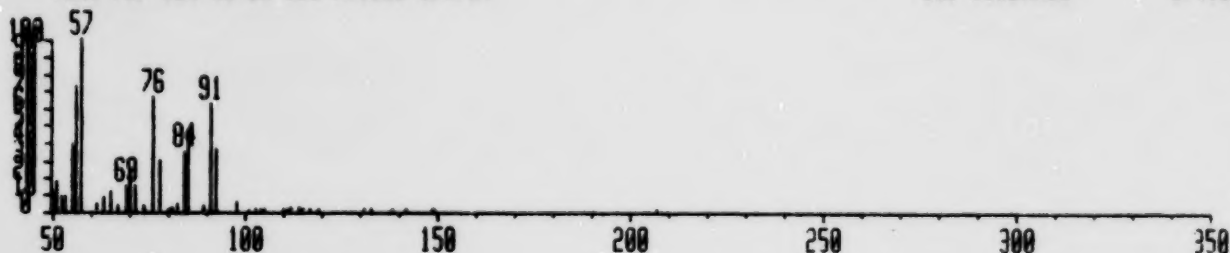
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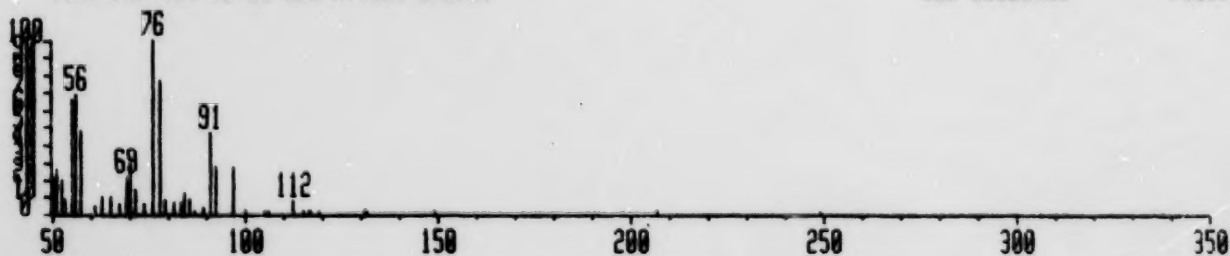
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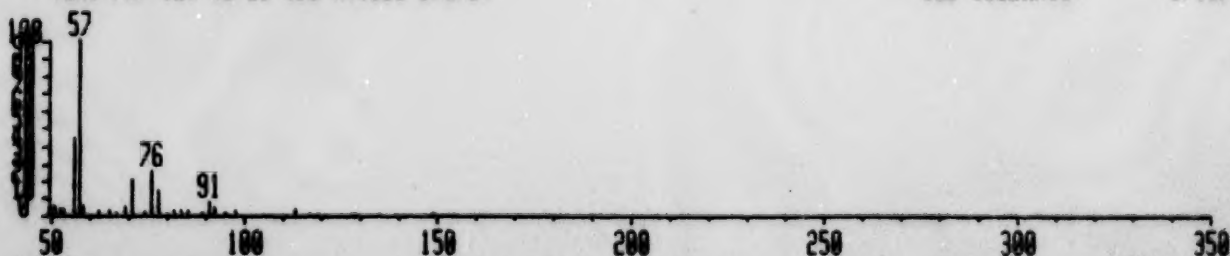
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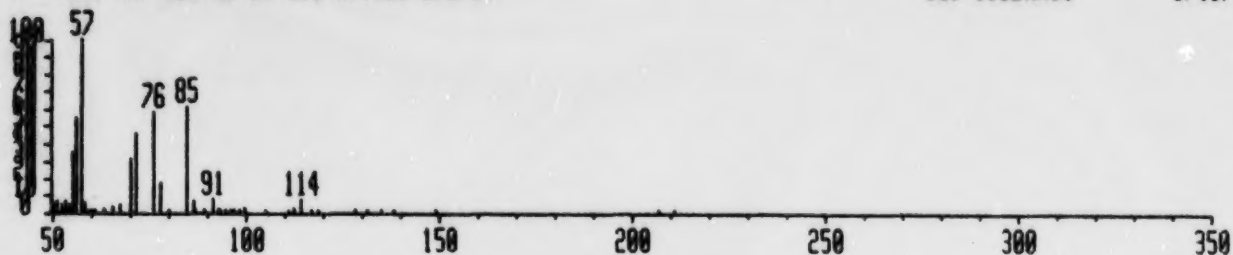
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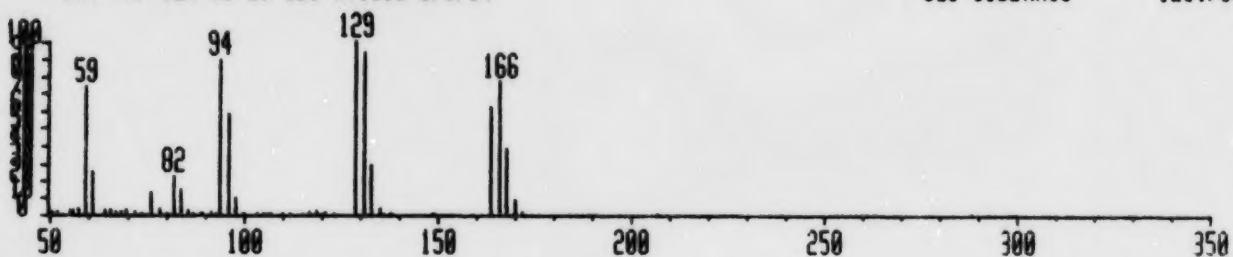
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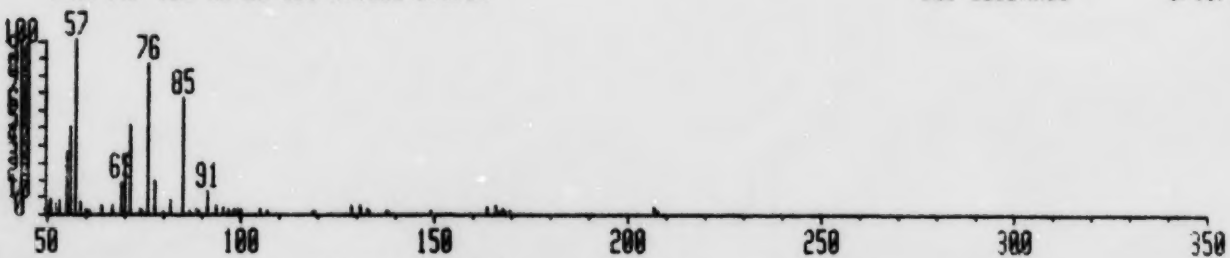
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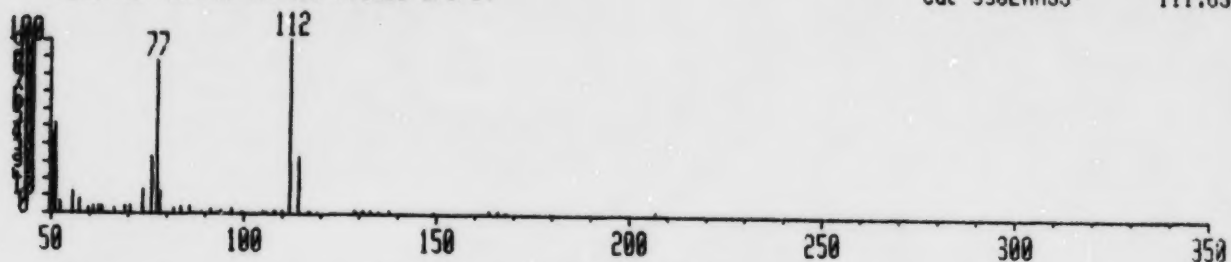
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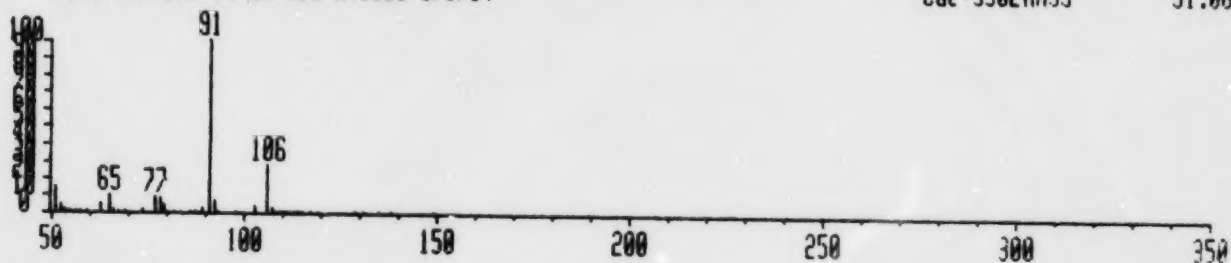
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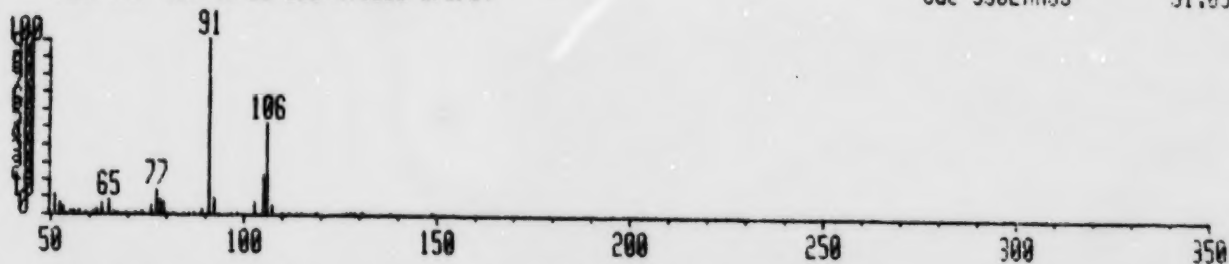
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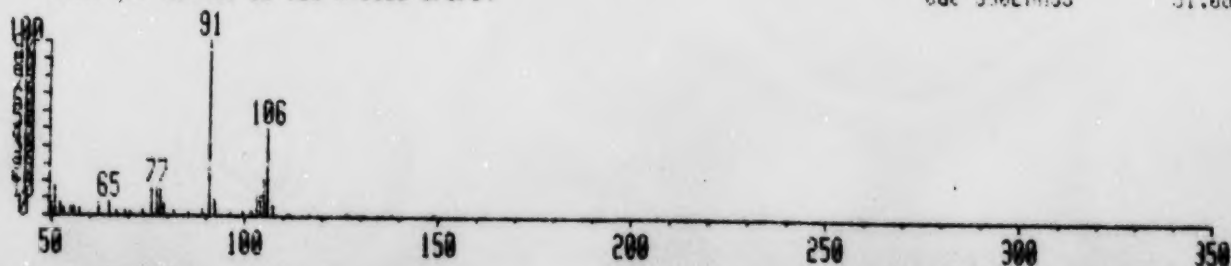
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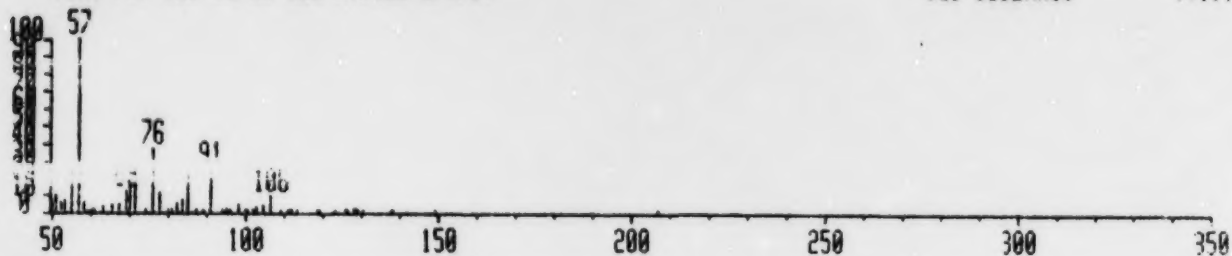
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BpM=91 I=1.1v Hm=206 TIC=19577000 Acnt GUELPH Sys: 350E HMR 7250000
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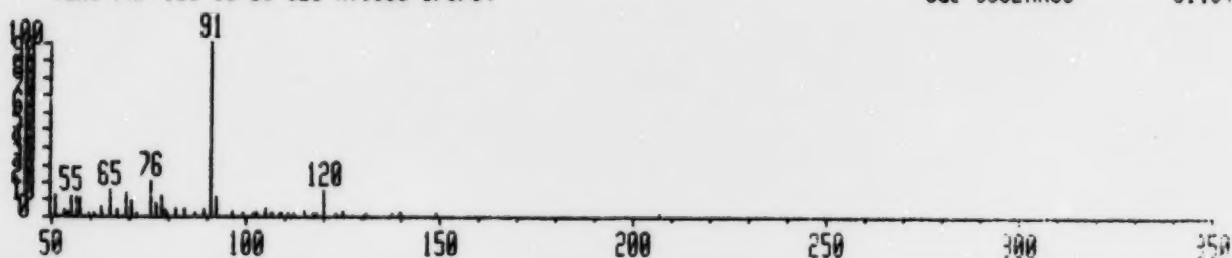
FHP123#124* x1 Bgd=110 9-AUG-84 16:07:00:02:36 12250 EI+
BpM=91 I=248mv Hm=206 TIC=5461000 Acnt GUELPH Sys: 350E HMR 1631000
Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS 91.061



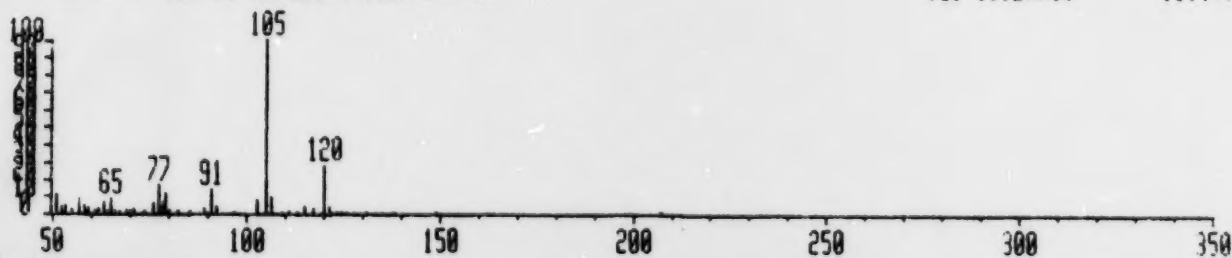
FHP123#128* x1 Bgd=110 9-AUG-84 16:07:00:02:41 12250 EI+
 BpM=57 I=81mv Hm=206 TIC=2075000 Acnt: GUELPH Sys: 350E HMR: 531000
 Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS: 56.850



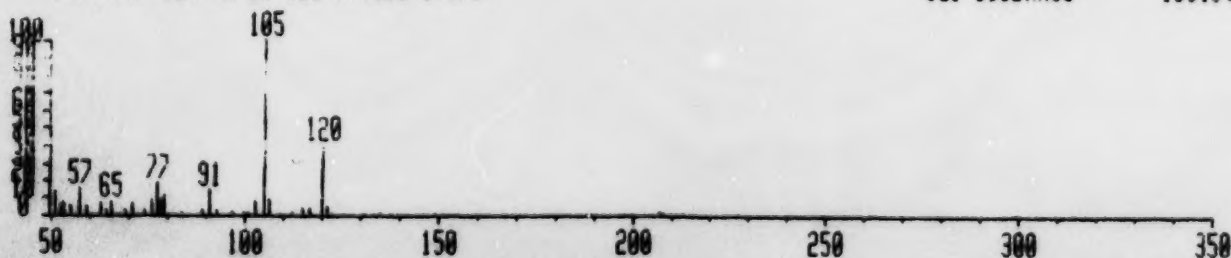
FHP123#158* x1 Bgd=110 9-AUG-84 16:07:00:03:17 12250 EI+
 BpM=91 I=106mv Hm=206 TIC=2120000 Acnt: GUELPH Sys: 350E HMR: 695000
 Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS: 91.045



FHP123#162* x1 Bgd=159 9-AUG-84 16:07:00:03:22 12250 EI+
 BpM=105 I=517mv Hm=207 TIC=9381000 Acnt: GUELPH Sys: 350E HMR: 3300000
 Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS: 105.450



FHP123#165* x1 Bgd=159 9-AUG-84 16:07:00:03:26 12250 EI+
 BpM=105 I=271mv Hm=207 TIC=5510000 Acnt: GUELPH Sys: 350E HMR: 1779000
 Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS: 105.045



FHP123#171* x1 Bgd=159 9-AUG-84 16:07:03:33 12250 EI+

BpM=105 I=245mv Hm=206 TIC=4508000

Acnt: GUELPH

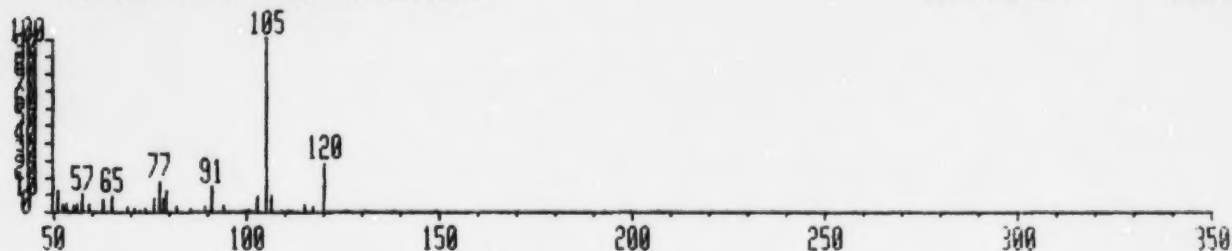
Sys: 350E HMR

1611000

Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350E MASS

105.055



FHP123#176* x1 Bgd=159 9-AUG-84 16:07:03:39 12250 EI+

BpM=57 I=39mv Hm=206 TIC=1436000

Acnt: GUELPH

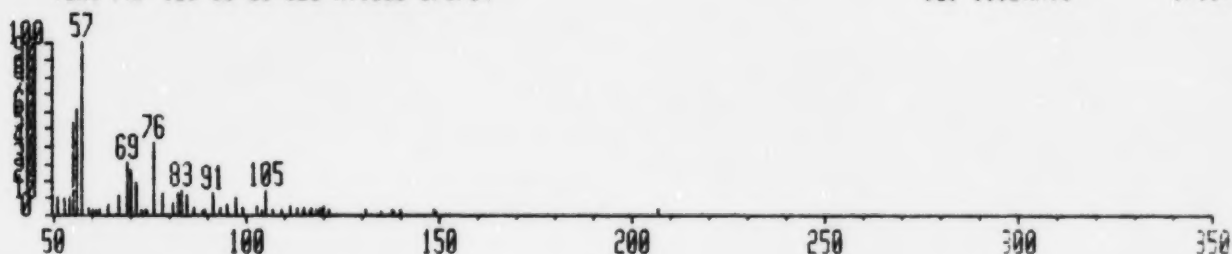
Sys: 350E HMR

261000

Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350E MASS

57.170



FHP123#178* x1 Bgd=177 9-AUG-84 16:07:03:41 12250 EI+

BpM=105 I=916mv Hm=280 TIC=16125000

Acnt: GUELPH

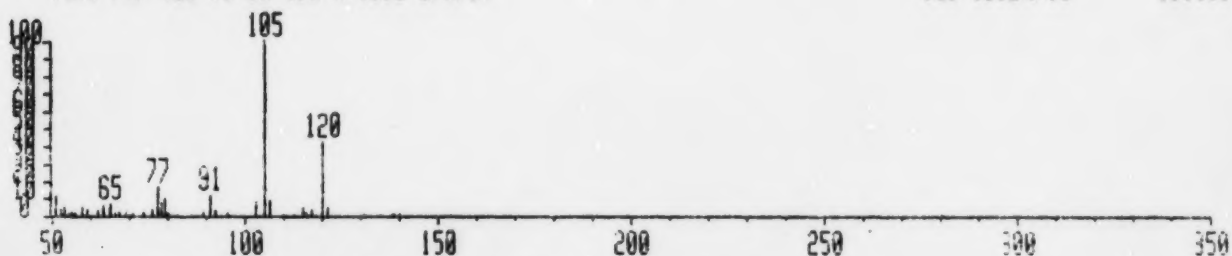
Sys: 350E HMR

6009000

Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350E MASS

105.053



FHP123#188* x1 Bgd=177 9-AUG-84 16:07:03:53 12250 EI+

BpM=146 I=36mv Hm=206 TIC=1543000

Acnt: GUELPH

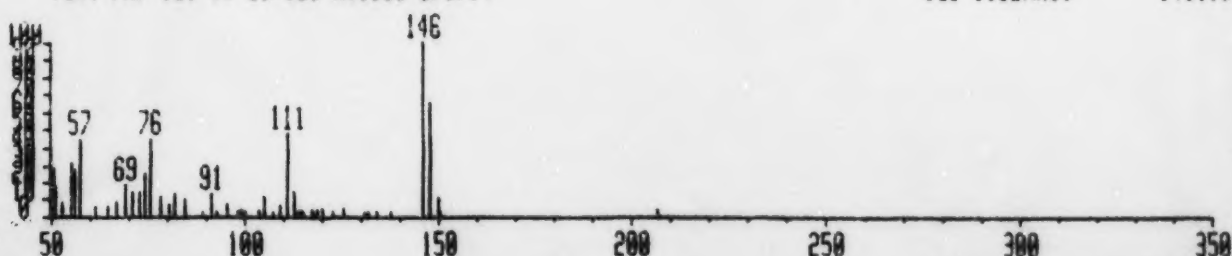
Sys: 350E HMR

236000

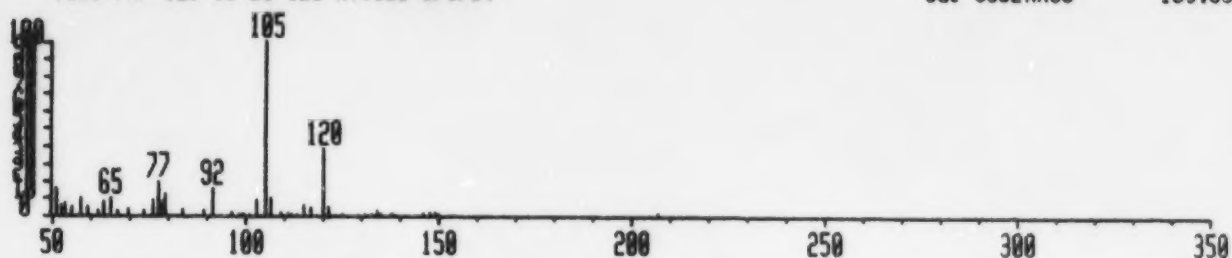
Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350E MASS

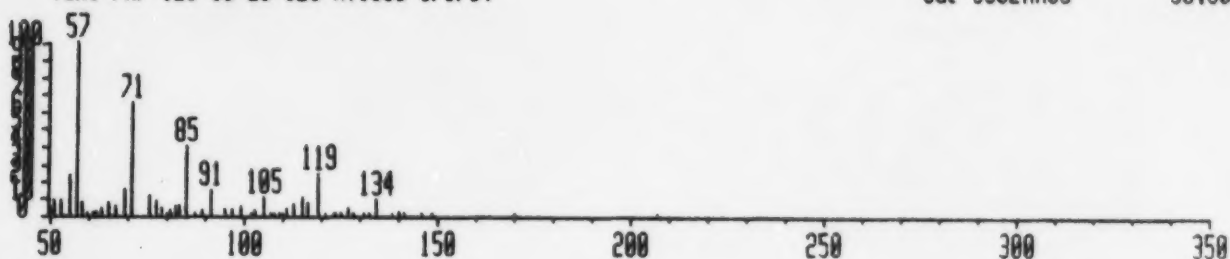
145.051



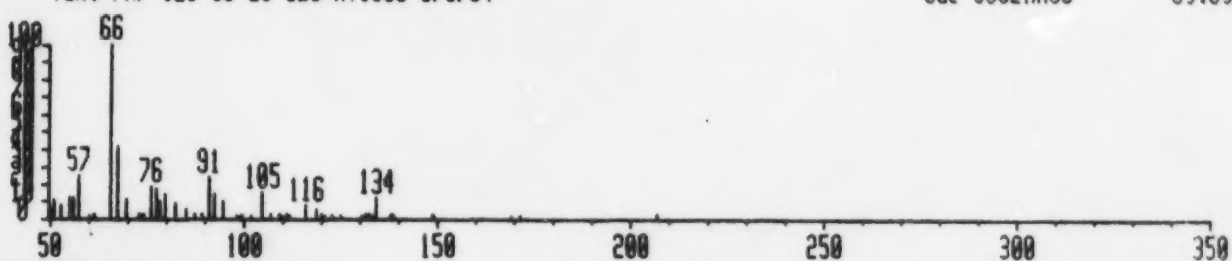
FHP1230193* x1 Bgd=177 9-AUG-84 16:07:0:03:59 12250 EI+
BpM=105 I=170mv Hm=206 TIC=3726000 Acnt:GUELPH Sys:350E HMR: 1167000
Text:FHP-123 50-20-320 MV1600 8/9/84 Cal:350EMASS: 105.056



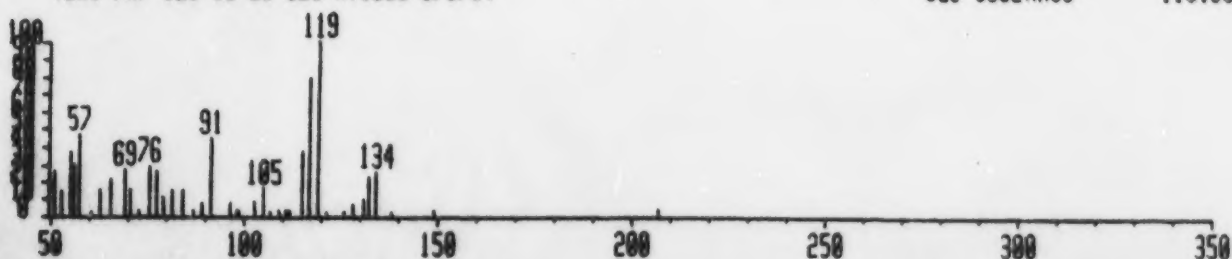
FHP1230211* x1 Bgd=203 9-AUG-84 16:07:0:04:21 12250 EI+
BpM=57 I=97mv Hm=206 TIC=2931000 Acnt:GUELPH Sys:350E HMR: 639000
Text:FHP-123 50-20-320 MV1600 8/9/84 Cal:350EMASS: 56.906



FHP1230216* x1 Bgd=203 9-AUG-84 16:07:0:04:27 12250 EI+
BpM=66 I=54mv Hm=206 TIC=1544000 Acnt:GUELPH Sys:350E HMR: 356000
Text:FHP-123 50-20-320 MV1600 8/9/84 Cal:350EMASS: 65.632



FHP1230224* x1 Bgd=203 9-AUG-84 16:07:0:04:37 12250 EI+
BpM=119 I=33mv Hm=206 TIC=1001000 Acnt:GUELPH Sys:350E HMR: 222000
Text:FHP-123 50-20-320 MV1600 8/9/84 Cal:350EMASS: 119.097



FHP1231228+ x1 Bgd=203 9-AUG-84 16:07:0:04:42 12250 EI+

BpM=57 I=66mv Hm=206 TIC=1391000

Acnt: GUELPH

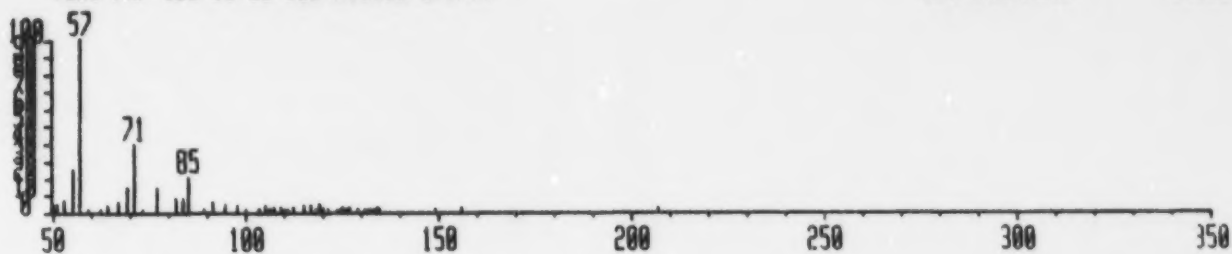
Sys: 350E HMR

437000

Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350EMASS

56.938



FHP1231260+ x1 Bgd=203 9-AUG-84 16:07:0:05:20 12250 EI+

BpM=104 I=190mv Hm=206 TIC=5794000

Acnt: GUELPH

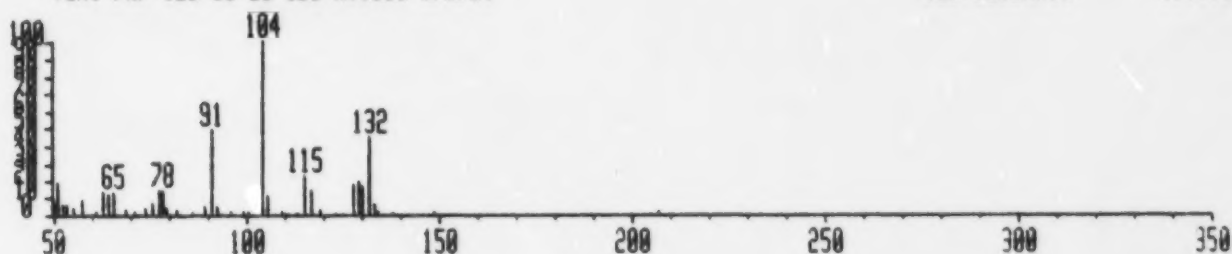
Sys: 350E HMR

1300000

Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350EMASS

103.803



FHP1231271+ x1 Bgd=265 9-AUG-84 16:07:0:05:34 12250 EI+

BpM=51 I=10v Hm=252 TIC=555374976

Acnt: GUELPH

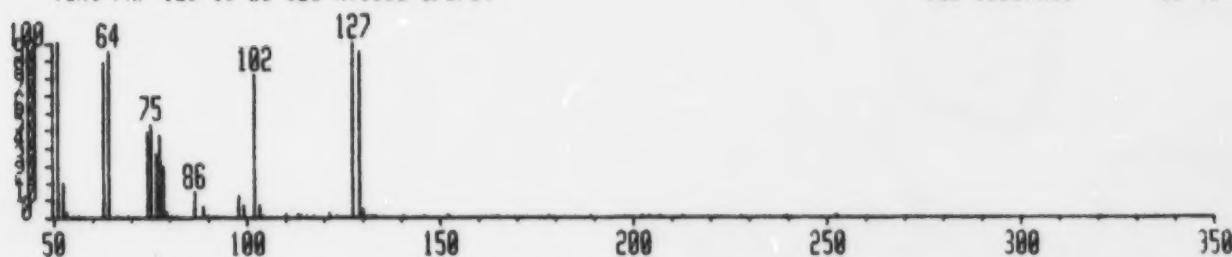
Sys: 350E HMR

65534000

Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350EMASS

127.341



FHP1231317+ x1 Bgd=265 9-AUG-84 16:07:0:06:29 12250 EI+

BpM=142 I=35mv Hm=206 TIC=1700000

Acnt: GUELPH

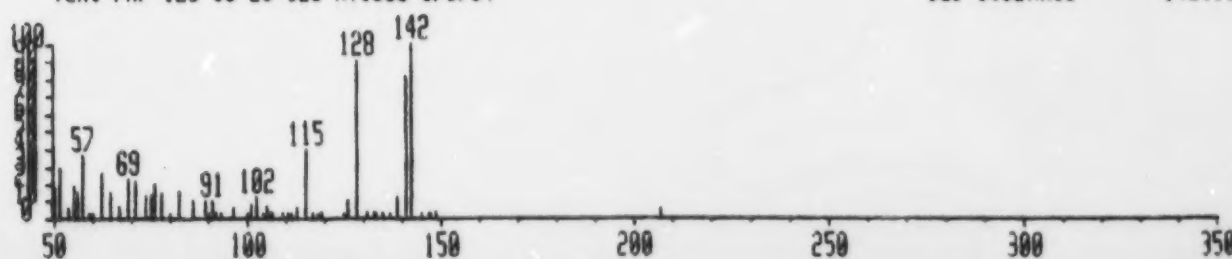
Sys: 350E HMR

232000

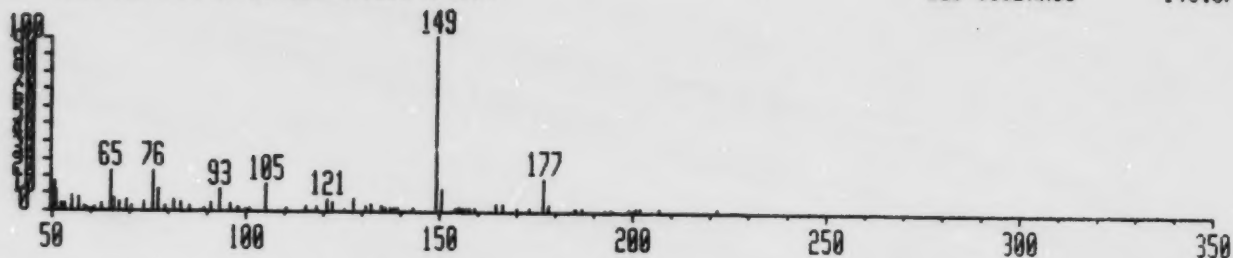
Text: FHP-123 50-20-320 MV1600 8/9/84

Cal: 350EMASS

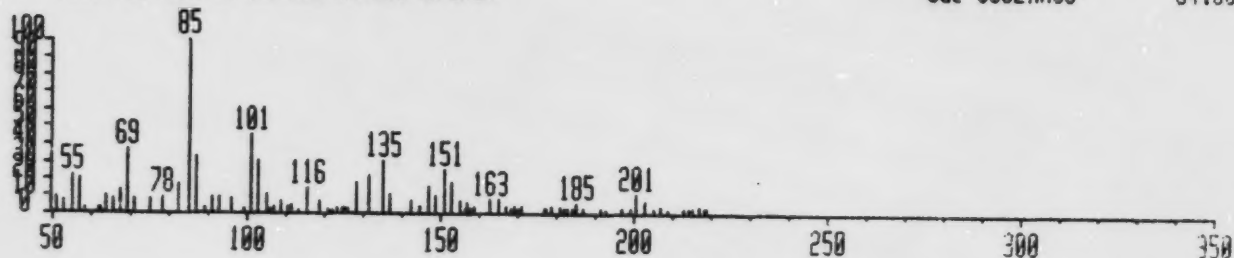
142.182



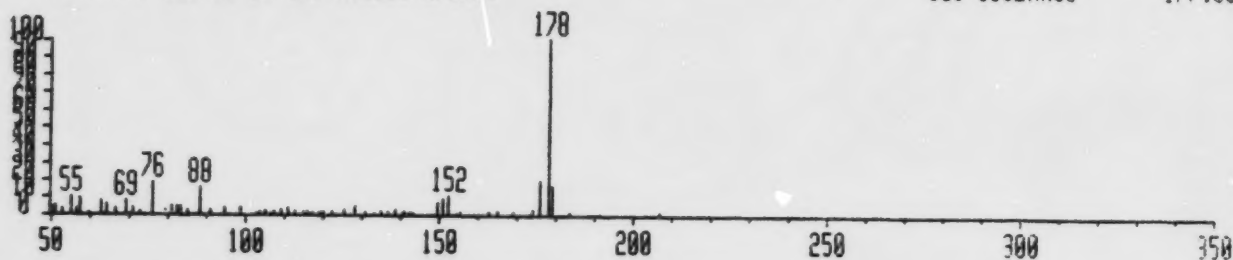
FHP123#426* x1 Bgd=265 9-AUG-84 16:07:00:41 12250 EI+
BpM=149 I=138mv Hm=221 TIC=3359000 Acnt GUELPH Sys 350E HMR 905000
Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS 148.877



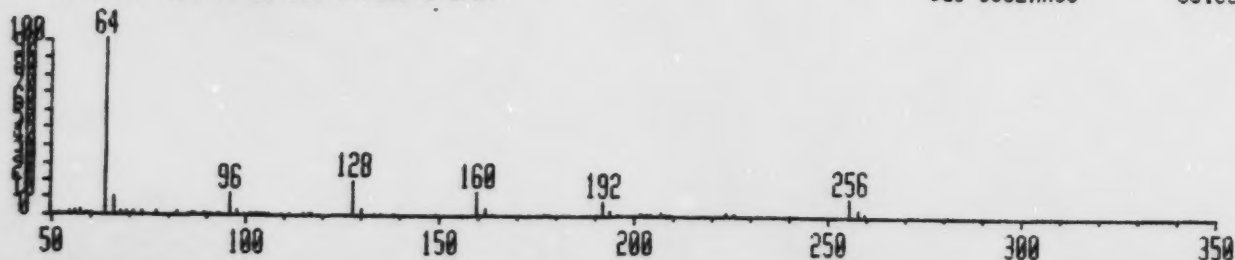
FHP123#445* x1 Bgd=265 9-AUG-84 16:07:00:09:04 12250 EI+
BpM=85 I=41mv Hm=218 TIC=1993000 Acnt GUELPH Sys 350E HMR 272000
Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS 84.967



FHP123#491* x1 Bgd=265 9-AUG-84 16:07:00:09:59 12250 EI+
BpM=178 I=152mv Hm=206 TIC=3146000 Acnt GUELPH Sys 350E HMR 990000
Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS 177.966



FHP123#570* x1 Bgd=265 9-AUG-84 16:07:00:11:35 12250 EI+
BpM=64 I=575mv Hm=Low TIC=7665000 Acnt GUELPH Sys 350E HMR 3800000
Text: FHP-123 50-20-320 MV1600 8/9/84 Cal: 350EMASS 63.850



APPENDIX III A

Mass spectrum of FHP Products
of Phenanthrene, ref: table 9

R90020 x1 Bgd=1 6-JUL-84 10:29:00:07 12250 EI+

BpM=76 I=57mv Hm=297 TIC=816000

Acnt:GUELPH

Sys:350E HMR:

379000

Text:SAMPLE 090 1600MV 50-10-320 7/6/84

Cal:350ENASS:

75.950



R90010 x1 Bgd=1 6-JUL-84 10:29:00:17 12250 EI+

BpM=76 I=46mv Hm=206 TIC=1015000

Acnt:GUELPH

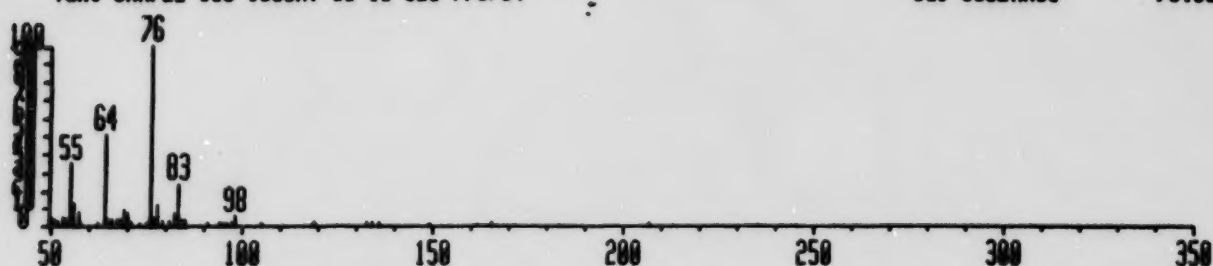
Sys:350E HMR:

303000

Text:SAMPLE 090 1600MV 50-10-320 7/6/84

Cal:350ENASS:

75.955



R90027 x1 Bgd=1 6-JUL-84 10:29:00:30 12250 EI+

BpM=76 I=53mv Hm=346 TIC=695000

Acnt:GUELPH

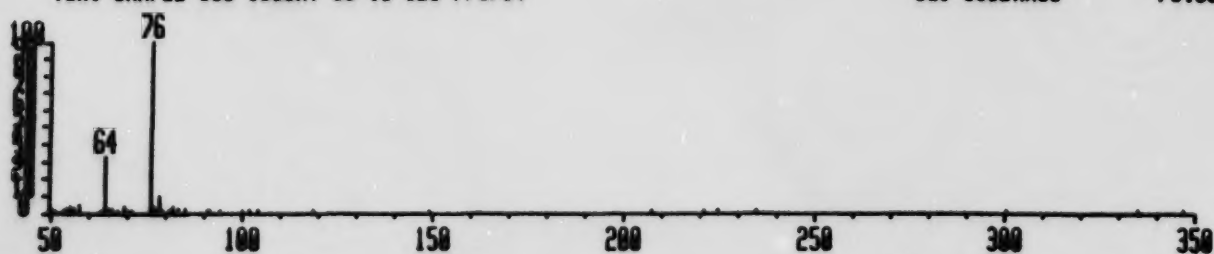
Sys:350E HMR:

353000

Text:SAMPLE 090 1600MV 50-10-320 7/6/84

Cal:350ENASS:

75.959



R90034 x1 Bgd=1 6-JUL-84 10:29:00:46 12250 EI+

BpM=91 I=50mv Hm=308 TIC=1205000

Acnt:GUELPH

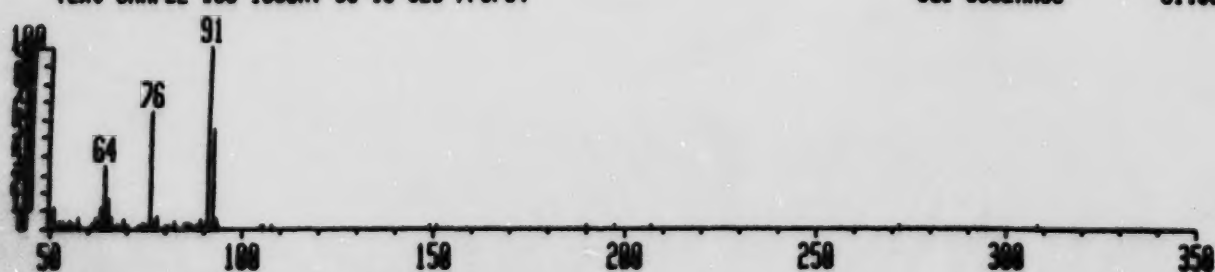
Sys:350E HMR:

333000

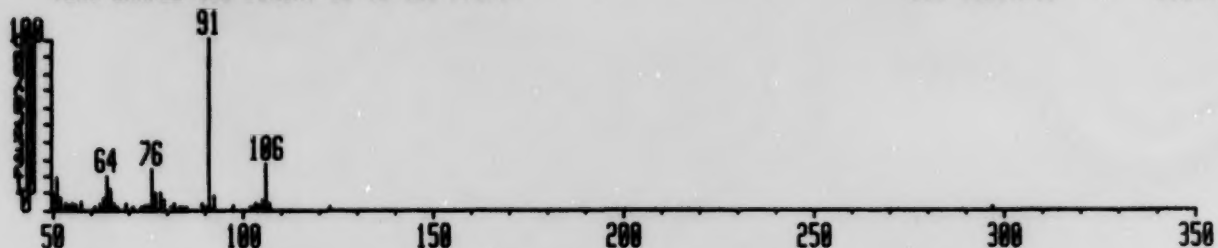
Text:SAMPLE 090 1600MV 50-10-320 7/6/84

Cal:350ENASS:

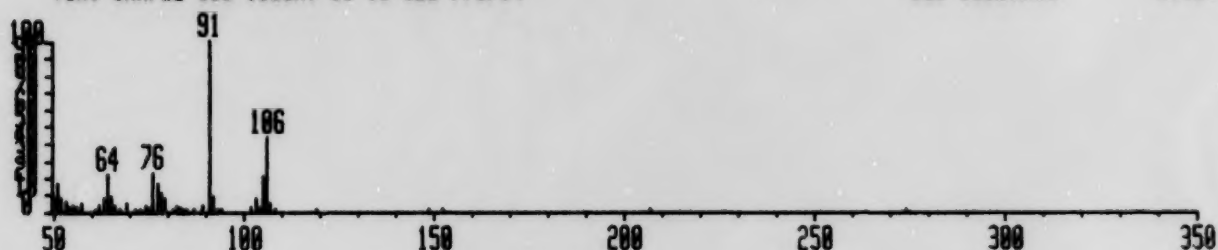
91.069



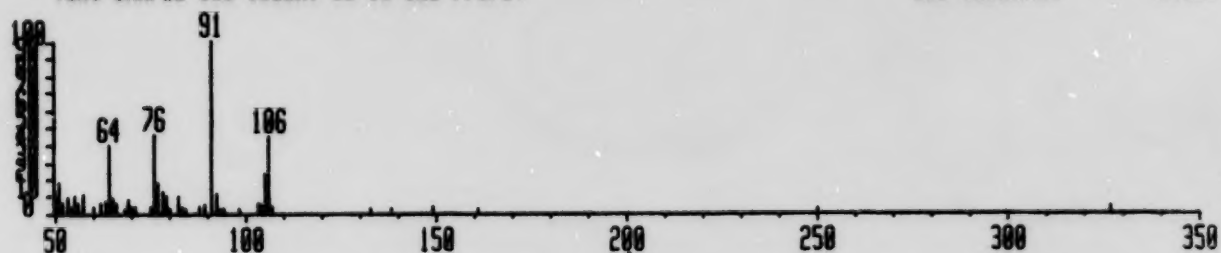
R90#101* x1 Bgd=1 6-JUL-84 10:29:02:07 12250 EI+
 BpM=91 I=50mv Hm=296 TIC=1052000 Acnt: GUELPH Sys: 350E HMR: 333000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 91.047



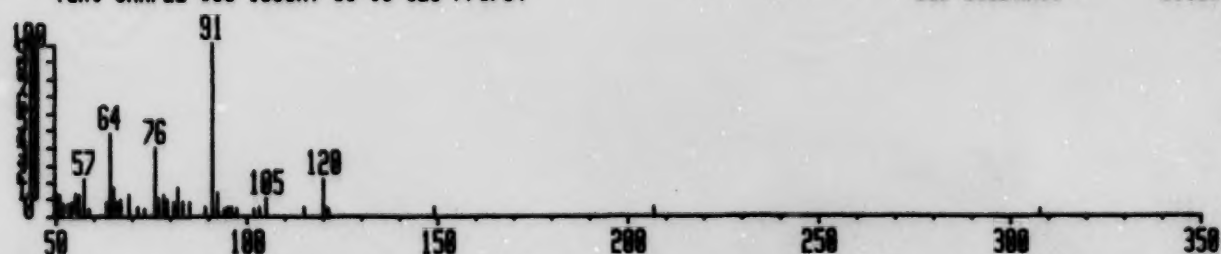
R90#107* x1 Bgd=1 6-JUL-84 10:29:02:14 12250 EI+
 BpM=91 I=40mv Hm=273 TIC=1171000 Acnt: GUELPH Sys: 350E HMR: 317000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 91.04



R90#126* x1 Bgd=1 6-JUL-84 10:29:02:37 12250 EI+
 BpM=91 I=21mv Hm=326 TIC=656000 Acnt: GUELPH Sys: 350E HMR: 13900
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 91.05

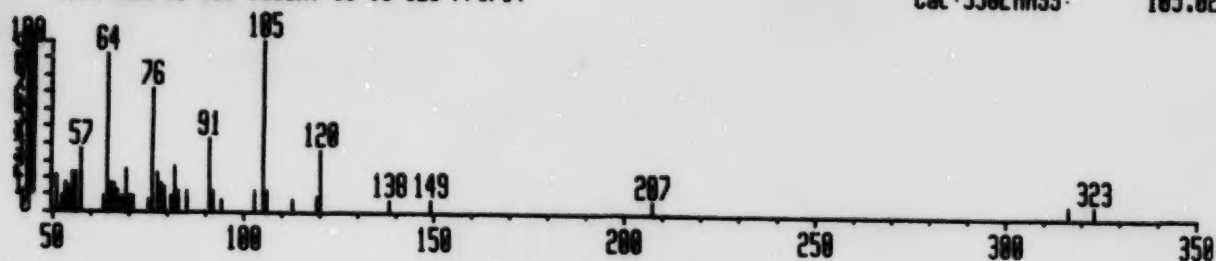


R90#179* x1 Bgd=1 6-JUL-84 10:29:03:41 12250 EI+
 BpM=91 I=13mv Hm=307 TIC=426000 Acnt: GUELPH Sys: 350E HMR: 8500
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 91.03



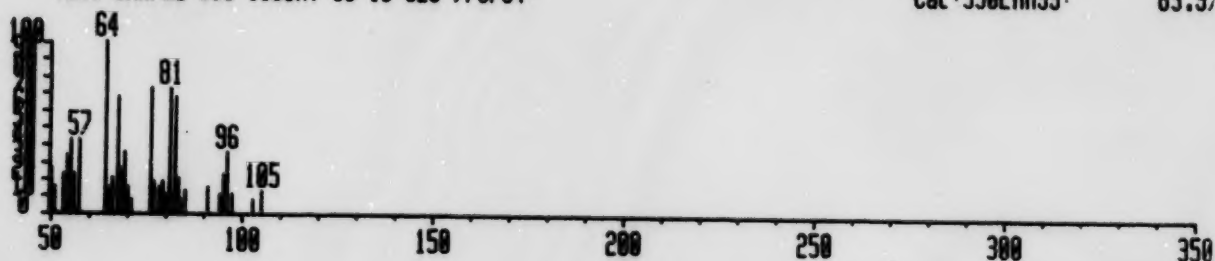
R90#186* x1 Bgd=1 6-JUL-84 10:29:0:03:50 12250 EI+
BpM=105 I=6.9uv Hm=323 TIC=364000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84

Acnt: GUELPH Sys: 350E HMR: 4500
Cal: 350EMASS: 105.02



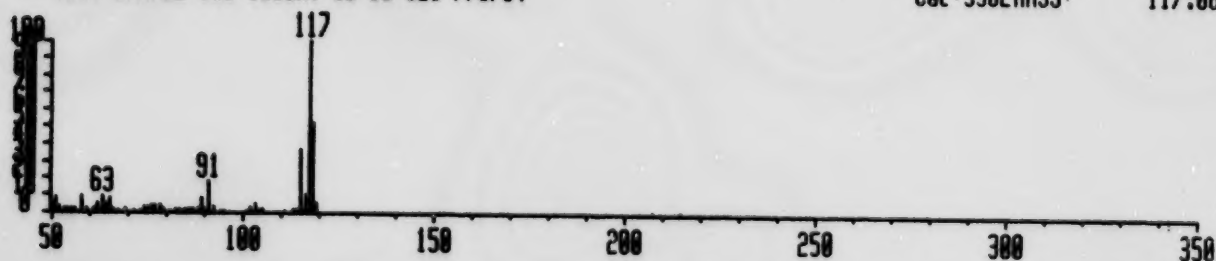
R90#200* x1 Bgd=1 6-JUL-84 10:29:0:04:16 12250 EI+
BpM=64 I=6.1uv Hm=105 TIC=365000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84

Acnt: GUELPH Sys: 350E HMR: 4000
Cal: 350EMASS: 63.97



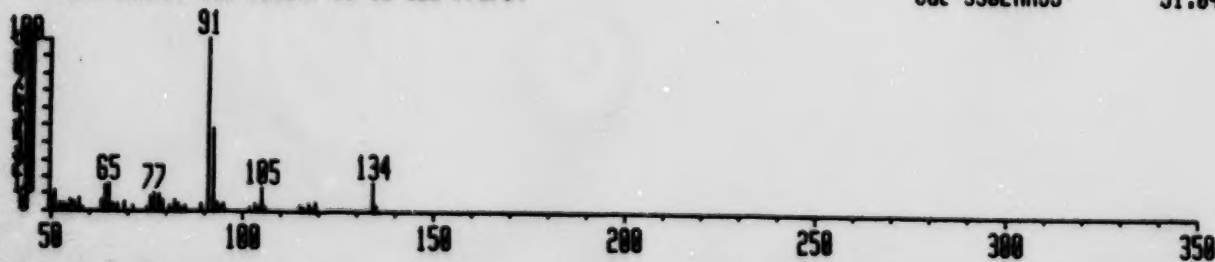
R90#250* x1 Bgd=1 6-JUL-84 10:29:0:05:07 12250 EI+
BpM=117 I=144uv Hm=214 TIC=2975000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84

Acnt: GUELPH Sys: 350E HMR: 94000
Cal: 350EMASS: 117.06



R90#269* x1 Bgd=1 6-JUL-84 10:29:0:05:30 12250 EI+
BpM=91 I=39uv Hm=135 TIC=889000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84

Acnt: GUELPH Sys: 350E HMR: 26000
Cal: 350EMASS: 91.04



R904296 x1 Bgd=1 6-JUL-84 10:29:0:06:02 12250 EI+
BpA=117 I=14uv Hm=207 TIC=576000
Text: SAMPLE #90 1600WV 50-10-320 7/6/84

Acnt: GUELPH

Sys: 350E

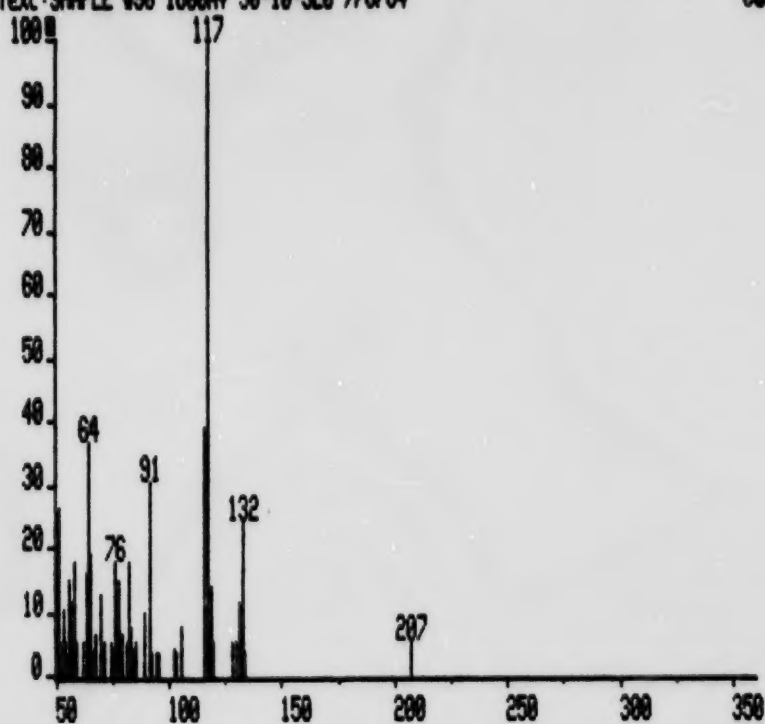
Cal: 350E

8296

N

1.00

95000



R904678 x1 Bgd=374 6-JUL-84 10:29:0:13:44 12250 EI+
BpA=129 I=87uv Hm=207 TIC=4820000
Text: SAMPLE #90 1600WV 50-10-320 7/6/84

Acnt: GUELPH

Sys: 350E

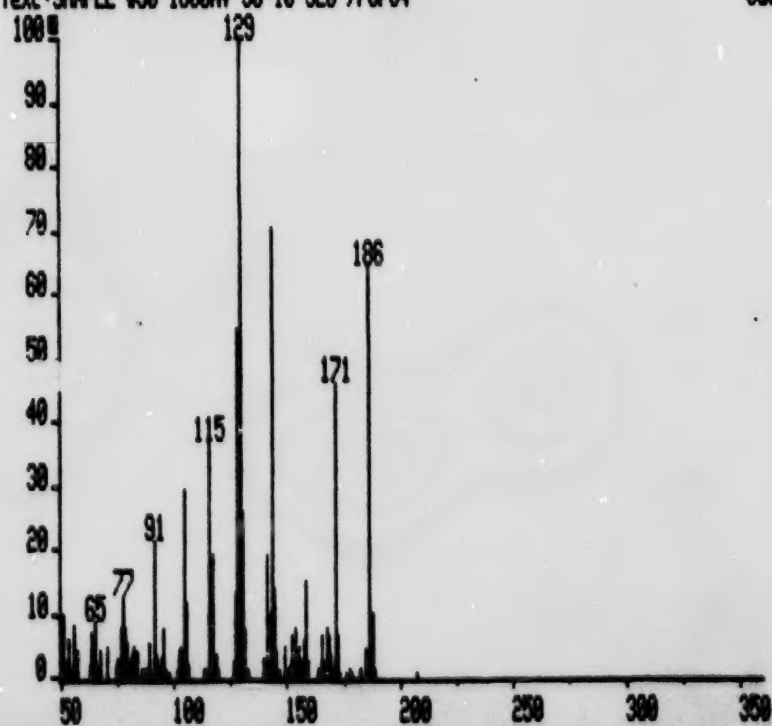
Cal: 350E

8678

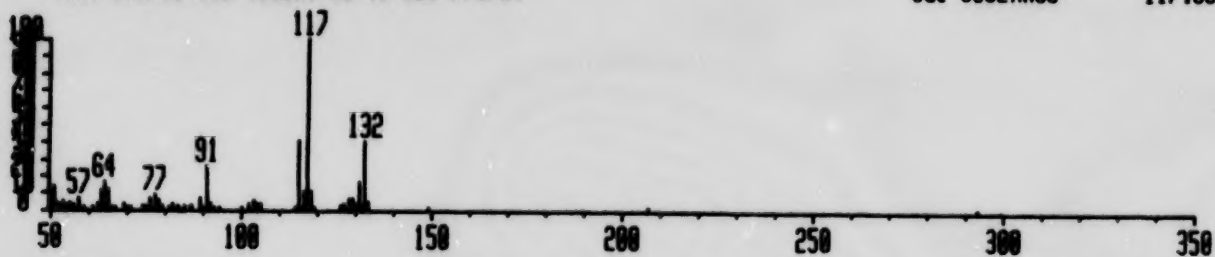
N

1.00

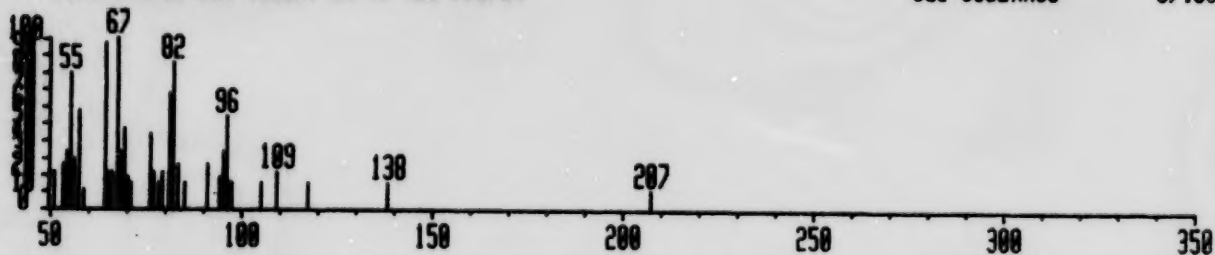
576000



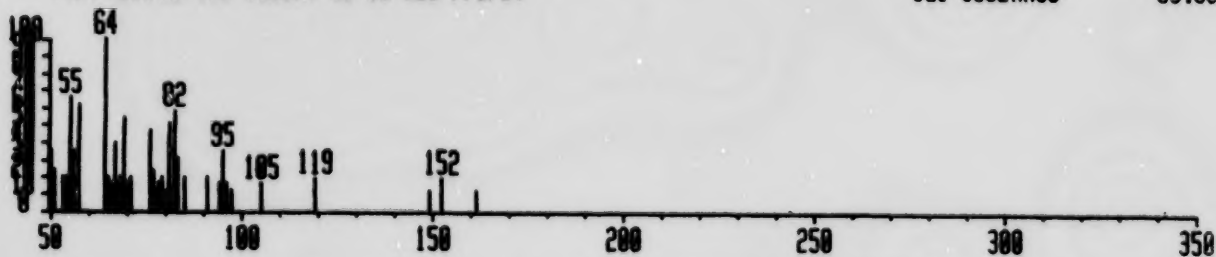
R901290 x1 Bgd=1 6-JUL-84 10:29:05:55 12250 EI+
 BpM=117 I=54mv Hm=293 TIC=1537000 Acnt:GUELPH Sys:350E HMR: 355001
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 117.061



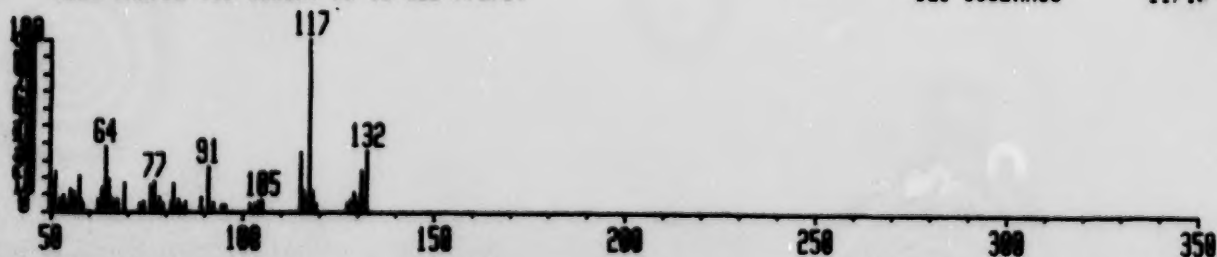
R901305 x1 Bgd=1 6-JUL-84 10:29:06:13 12250 EI+
 BpM=67 I=4.3mv Hm=207 TIC=322000 Acnt:GUELPH Sys:350E HMR: 2000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 67.06



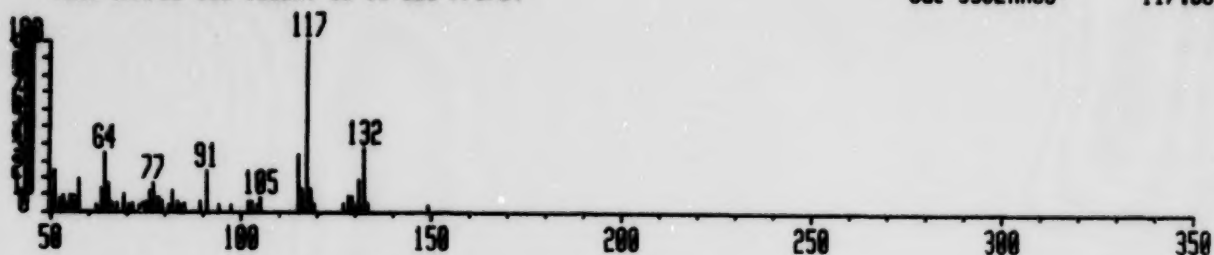
R901314 x1 Bgd=1 6-JUL-84 10:29:06:24 12250 EI+
 BpM=64 I=4.8mv Hm=161 TIC=259000 Acnt:GUELPH Sys:350E HMR: 2600
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 63.96



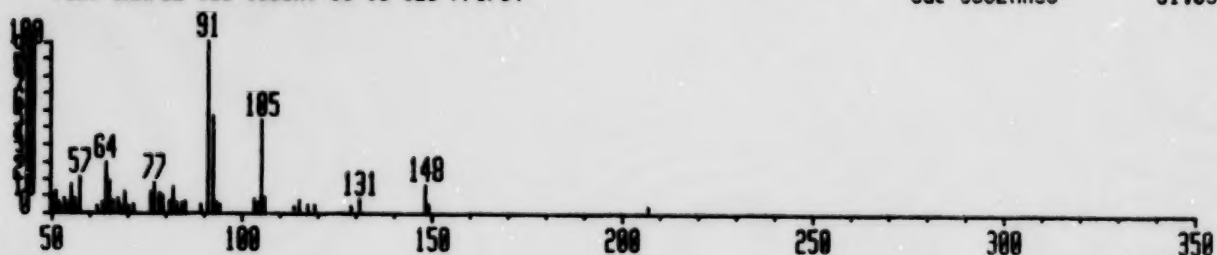
R901340 x1 Bgd=1 6-JUL-84 10:29:06:56 12250 EI+
 BpM=117 I=13mv Hm=132 TIC=557000 Acnt:GUELPH Sys:350E HMR: 9000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 117.06



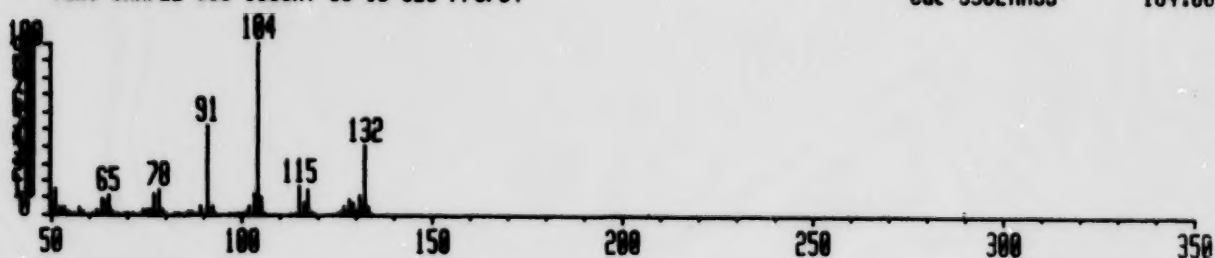
R900349* x1 Bgd=1 6-JUL-84 10:29:07:06 12250 EI+
BpM=117 I=17mv Hm=148 TIC=633000 Acnt:GUELPH Sys:350E HMR: 114000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 117.06



R900355* x1 Bgd=1 6-JUL-84 10:29:07:14 12250 EI+
BpM=91 I=13mv Hm=206 TIC=513000 Acnt:GUELPH Sys:350E HMR: 9100
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 91.05



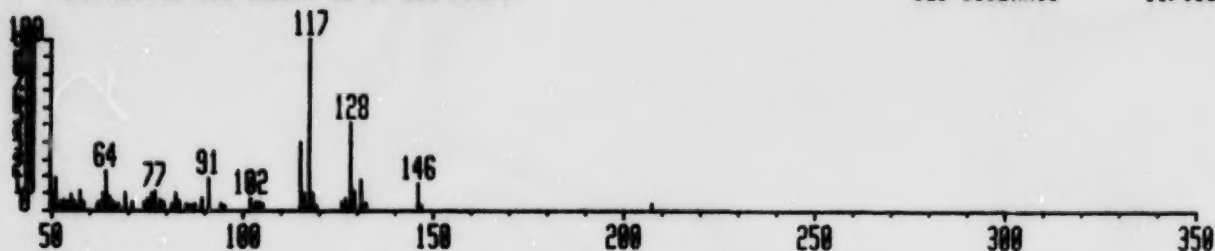
R900358* x1 Bgd=356 6-JUL-84 10:29:07:17 12250 EI+
BpM=104 I=674mv Hm=206 TIC=17545000 Acnt:GUELPH Sys:350E HMR: 441700
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 104.00



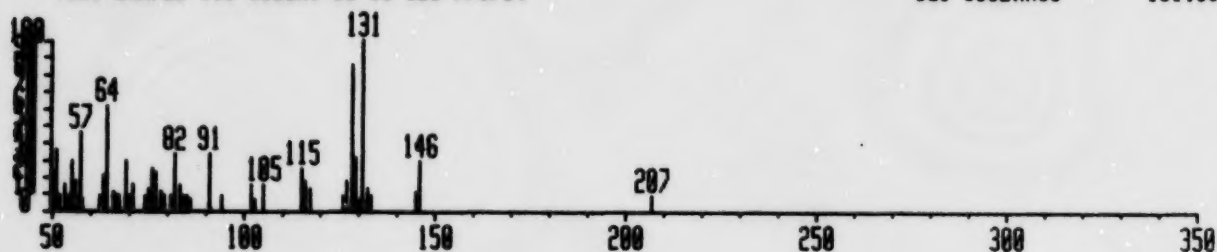
R900376* x1 Bgd=374 6-JUL-84 10:29:07:39 12250 EI+
BpM=120 I=1.4v Hm=146 TIC=10970000 Acnt:GUELPH Sys:350E HMR: 890300
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 120.11



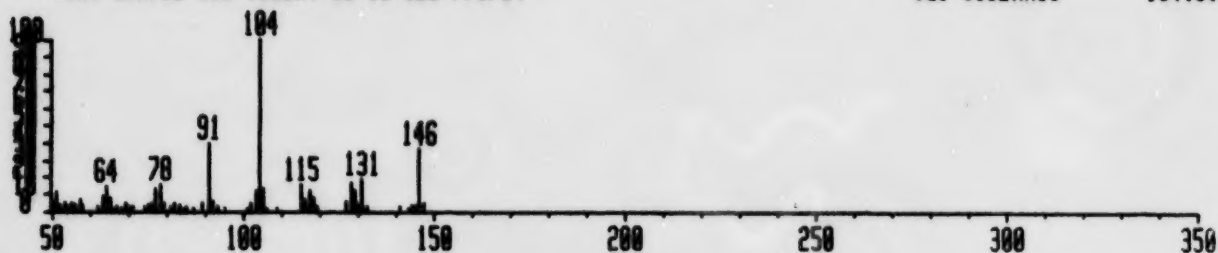
R901304+ x1 Bgd=374 6-JUL-84 10:29:0:07:49 12250 EI+
BpM=117 I=20mv Hm=207 TIC=709000 Acnt:GUELPH Sys:350E HMR: 132000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 117.050



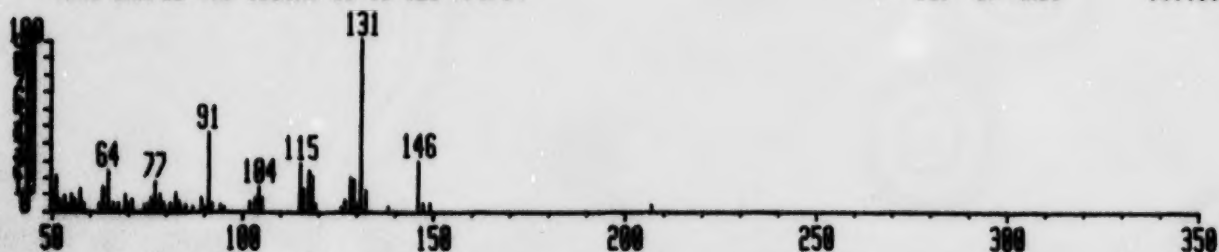
R901300+ x1 Bgd=374 6-JUL-84 10:29:0:07:54 12250 EI+
BpM=131 I=7.5mv Hm=206 TIC=469000 Acnt:GUELPH Sys:350E HMR: 49000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 131.000



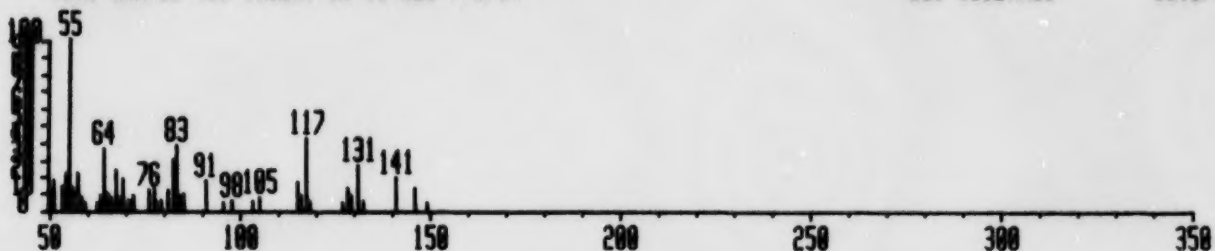
R901402+ x1 Bgd=374 6-JUL-84 10:29:0:00:10 12250 EI+
BpM=104 I=43mv Hm=147 TIC=1331000 Acnt:GUELPH Sys:350E HMR: 20200
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 104.000



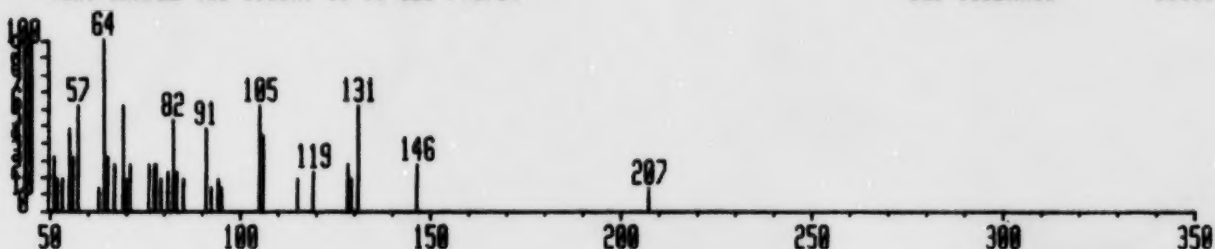
R901410+ x1 Bgd=374 6-JUL-84 10:29:0:00:20 12250 EI+
BpM=131 I=19mv Hm=206 TIC=700000 Acnt:GUELPH Sys:350E HMR: 12000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 131.000



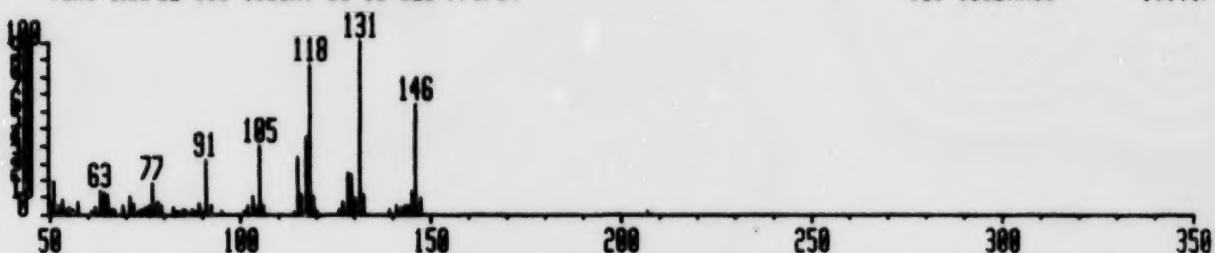
R900417+ x1 Bgd=374 6-JUL-84 10:29:00:29 12250 EI+
 BpM=55 I=11mv Hm=140 TIC=409000 Acnt:GUELPH Sys:350E HMR: 72000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal:350EMASS: 55.07%



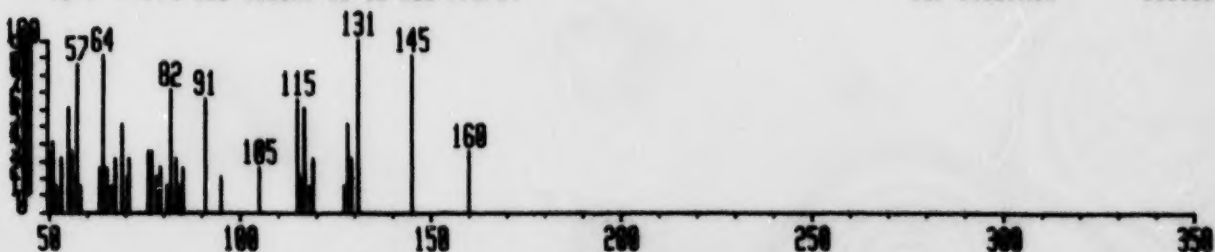
R900430+ x1 Bgd=374 6-JUL-84 10:29:00:44 12250 EI+
 BpM=64 I=3.5mv Hm=207 TIC=245000 Acnt:GUELPH Sys:350E HMR: 23000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal:350EMASS: 63.99%



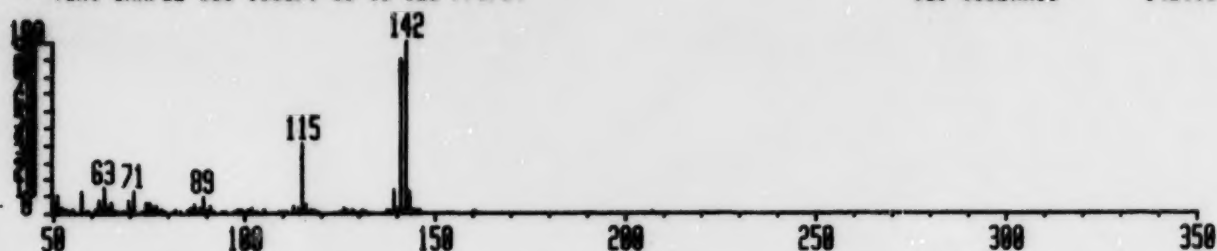
R900441+ x1 Bgd=374 6-JUL-84 10:29:00:50 12250 EI+
 BpM=131 I=56mv Hm=206 TIC=2670000 Acnt:GUELPH Sys:350E HMR: 37000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal:350EMASS: 131.17%



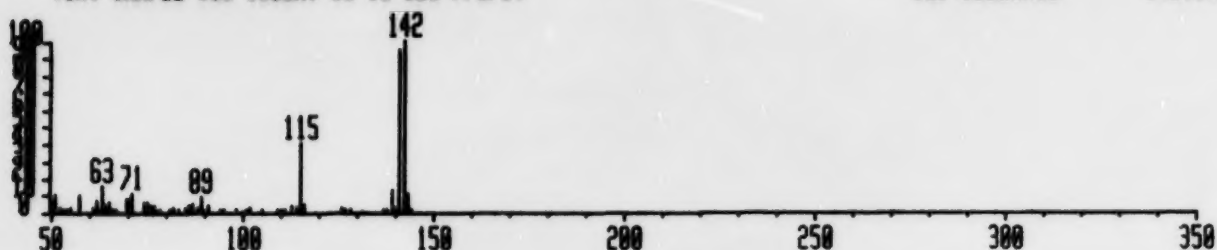
R900449+ x1 Bgd=374 6-JUL-84 10:29:00:07 12250 EI+
 BpM=131 I=3.1mv Hm=160 TIC=290000 Acnt:GUELPH Sys:350E HMR: 2000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal:350EMASS: 131.00%



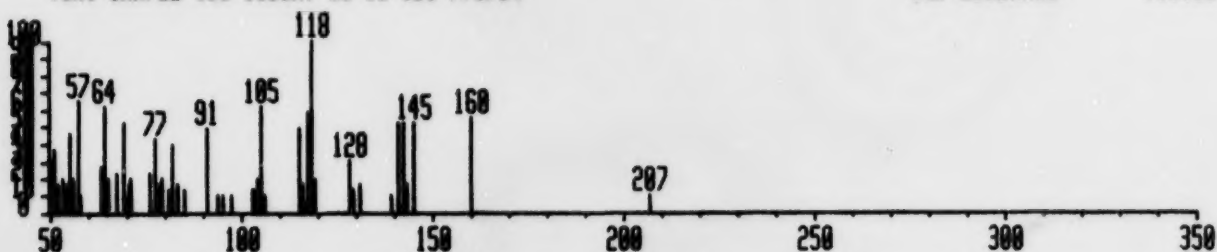
R900464* x1 Bgd=374 6-JUL-84 10:29:08:25 12250 EI+
BpM=142 I=200mv Hn=207 TIC=5506000 Acnt:GUELPH Sys:350E HMR: 1366000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 142.184



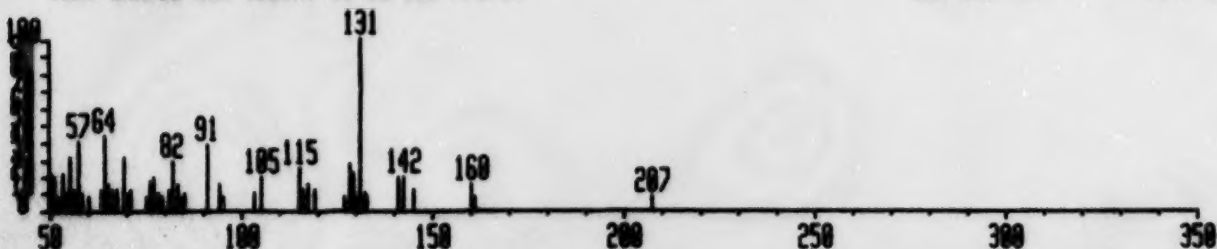
R900477* x1 Bgd=374 6-JUL-84 10:29:08:41 12250 EI+
BpM=142 I=94mv Hn=144 TIC=2592000 Acnt:GUELPH Sys:350E HMR: 616000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 142.182



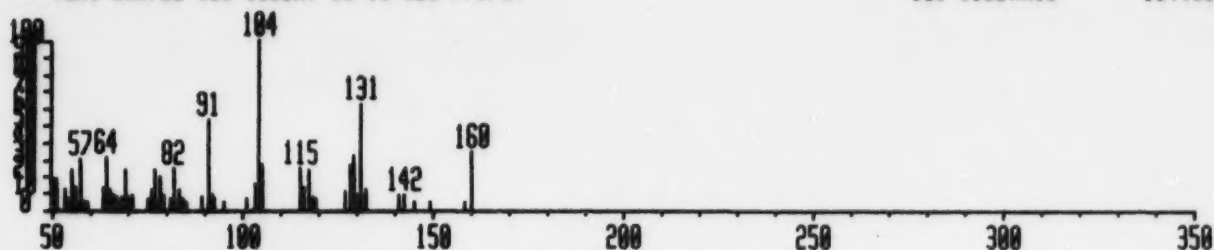
R900482* x1 Bgd=374 6-JUL-84 10:29:08:47 12250 EI+
BpM=118 I=4.7mv Hn=206 TIC=430000 Acnt:GUELPH Sys:350E HMR: 31001
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 118.061



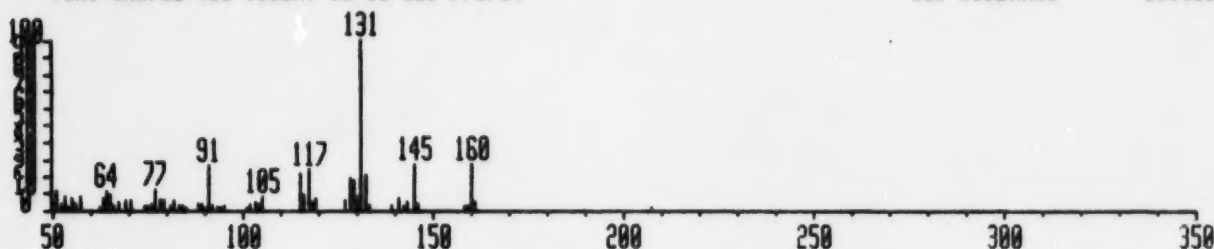
R900486* x1 Bgd=374 6-JUL-84 10:29:08:52 12250 EI+
BpM=131 I=6.4mv Hn=207 TIC=369000 Acnt:GUELPH Sys:350E HMR: 4200
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 131.98



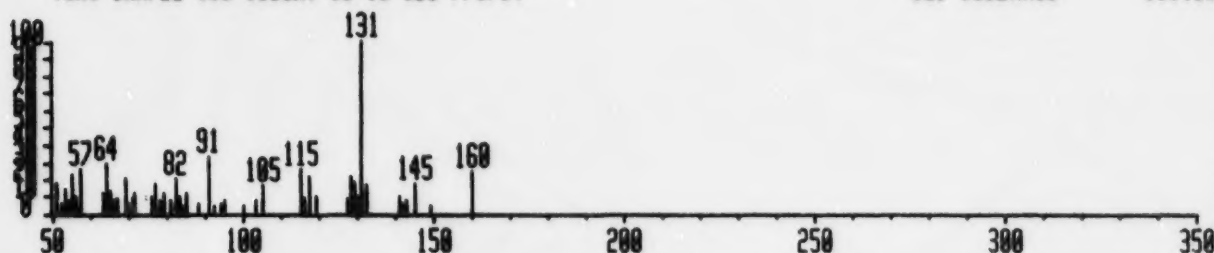
R900491* x1 Bgd=374 6-JUL-84 10:29:0:09:50 12250 EI+
BpM=104 I=10mv Hm=160 TIC=605000 Acnt:GUELPH Sys:350E HMR: 69000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 104.002



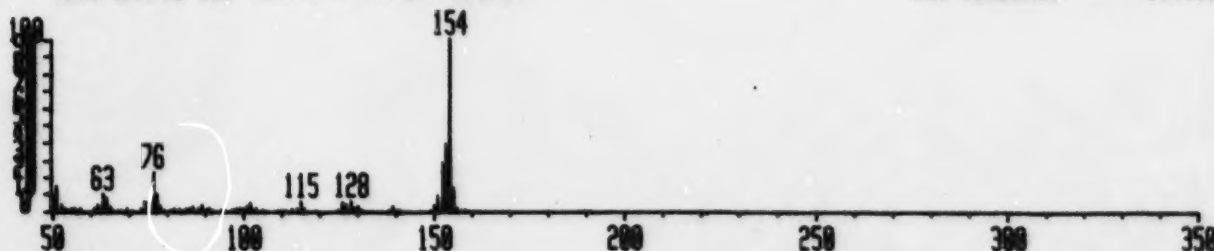
R900512* x1 Bgd=374 6-JUL-84 10:29:0:10:23 12250 EI+
BpM=131 I=41mv Hm=207 TIC=1374000 Acnt:GUELPH Sys:350E HMR: 273000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 131.004



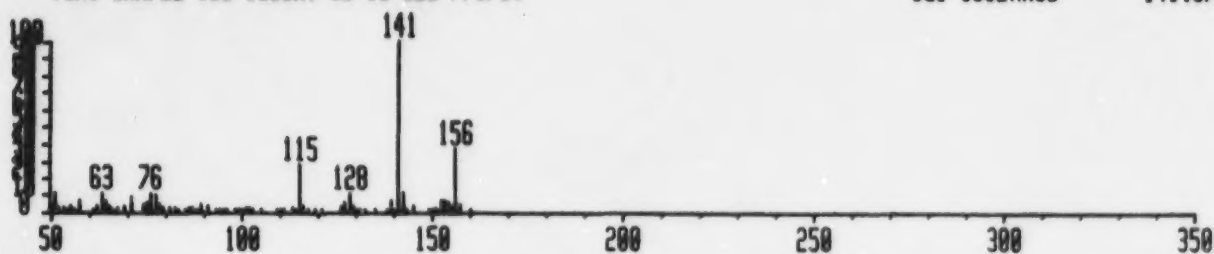
R900524* x1 Bgd=374 6-JUL-84 10:29:0:10:30 12250 EI+
BpM=131 I=10mv Hm=160 TIC=496000 Acnt:GUELPH Sys:350E HMR: 71000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 131.004



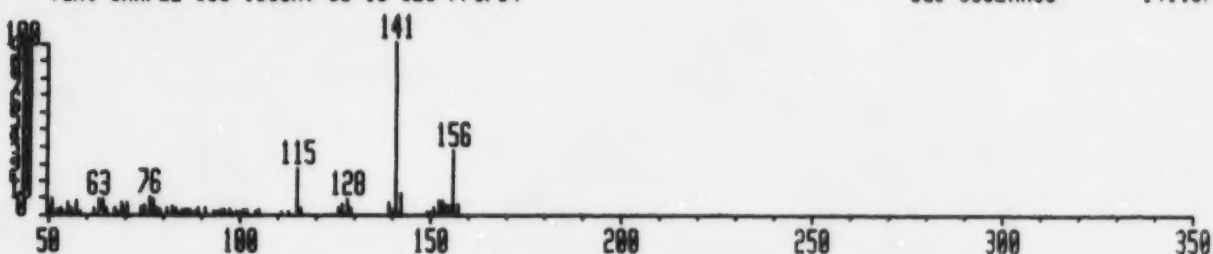
R900527* x1 Bgd=374 6-JUL-84 10:29:0:10:41 12250 EI+
BpM=154 I=200mv Hm=150 TIC=4695000 Acnt:GUELPH Sys:350E HMR: 1366000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 154.104



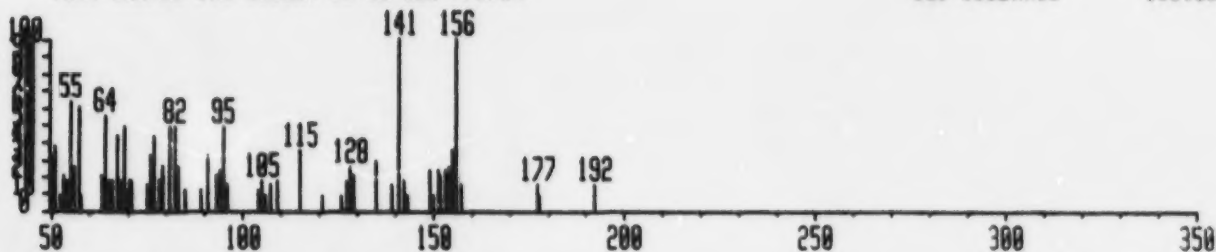
R900530* x1 Bgd=374 6-JUL-04 10:29:0:10:55 12250 EI+
 BpM=141 I=93mv Hm=160 TIC=2390000 Acnt:GUELPH Sys:350E HMR: 612000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/04 Cal: 350EMASS: 141.070



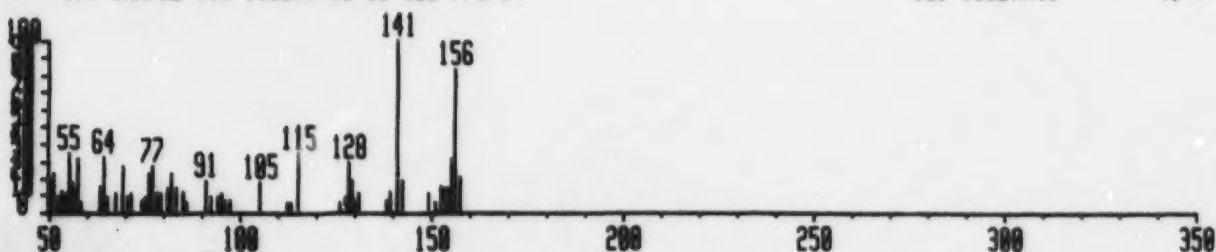
R900540* x1 Bgd=374 6-JUL-04 10:29:0:10:57 12250 EI+
 BpM=141 I=44mv Hm=157 TIC=1163000 Acnt:GUELPH Sys:350E HMR: 291000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/04 Cal: 350EMASS: 141.070



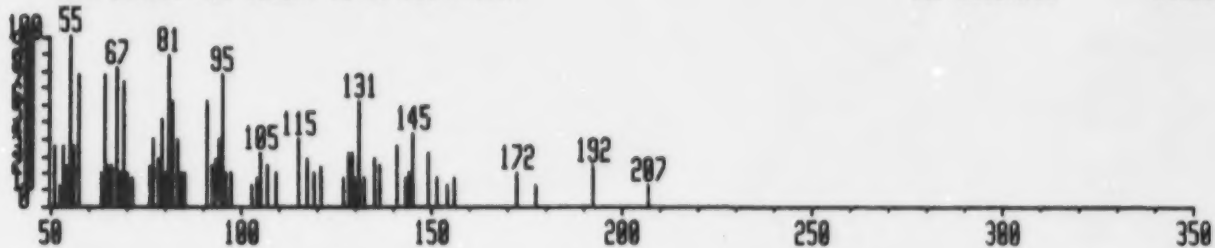
R900546* x1 Bgd=374 6-JUL-04 10:29:0:11:04 12250 EI+
 BpM=141 I=5.3mv Hm=192 TIC=563000 Acnt:GUELPH Sys:350E HMR: 3500
 Text: SAMPLE #90 1600MV 50-10-320 7/6/04 Cal: 350EMASS: 156.00



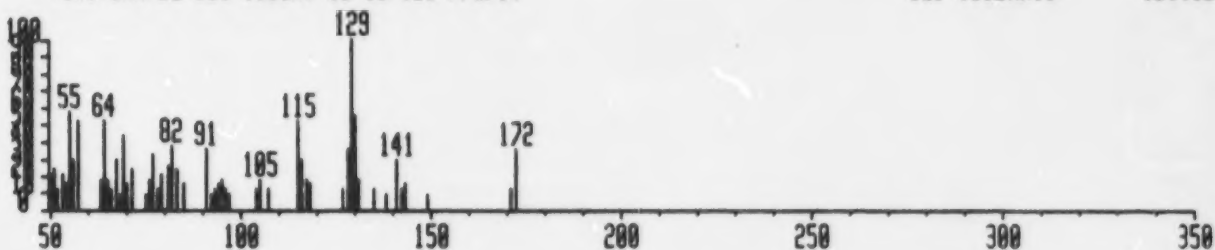
R900556* x1 Bgd=374 6-JUL-04 10:29:0:11:16 12250 EI+
 BpM=141 I=9.2mv Hm=157 TIC=561000 Acnt:GUELPH Sys:350E HMR: 6000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/04 Cal: 350EMASS: 41.070



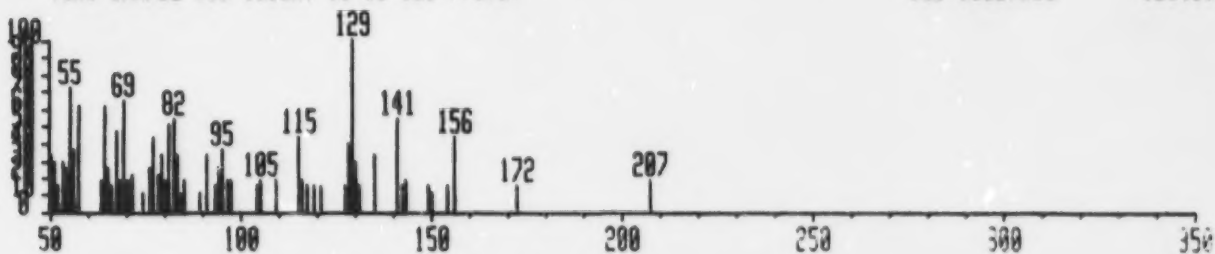
R900562* x1 Bgd=374 6-JUL-84 10:29:0:11:24 12250 EI+
 BpM=55 I=4.0mv Hm=207 TIC=510000 Acnt:GUELPH Sys:350E HMR: 26000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 55.061



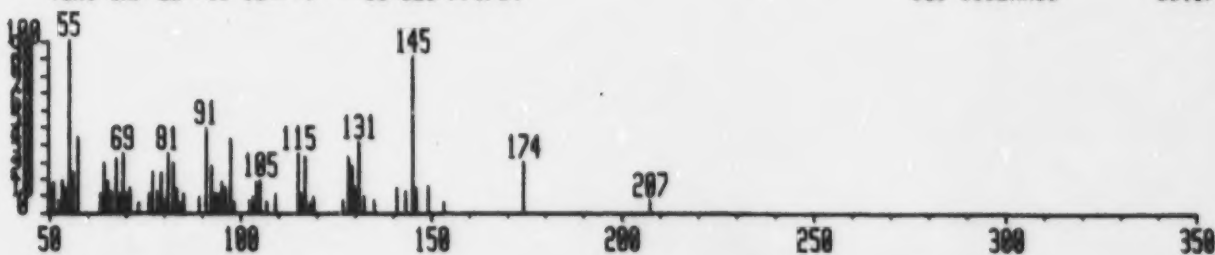
R900567* x1 Bgd=374 6-JUL-84 10:29:0:11:30 12250 EI+
 BpM=129 I=5.3mv Hm=172 TIC=431000 Acnt:GUELPH Sys:350E HMR: 35000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 129.021



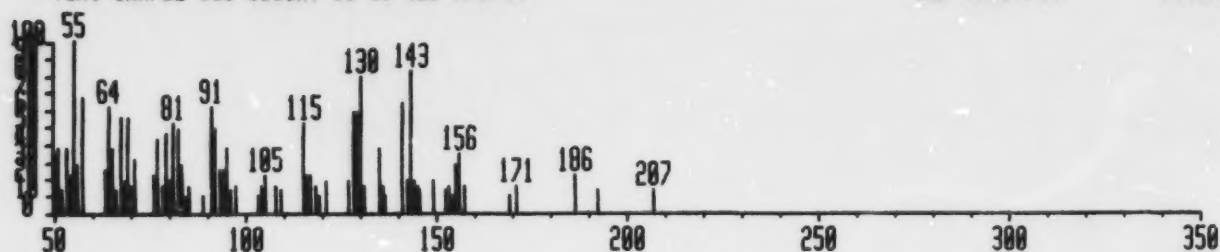
R900572* x1 Bgd=374 6-JUL-84 10:29:0:11:36 12250 EI+
 BpM=129 I=4.3mv Hm=207 TIC=465000 Acnt:GUELPH Sys:350E HMR: 2000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 129.03



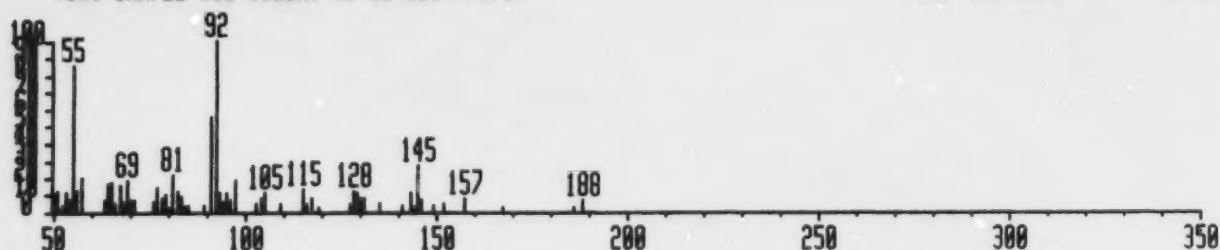
R900577* x1 Bgd=374 6-JUL-84 10:29:0:11:42 12250 EI+
 BpM=55 I=9.2mv Hm=207 TIC=735000 Acnt:GUELPH Sys:350E HMR: 6000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 55.07



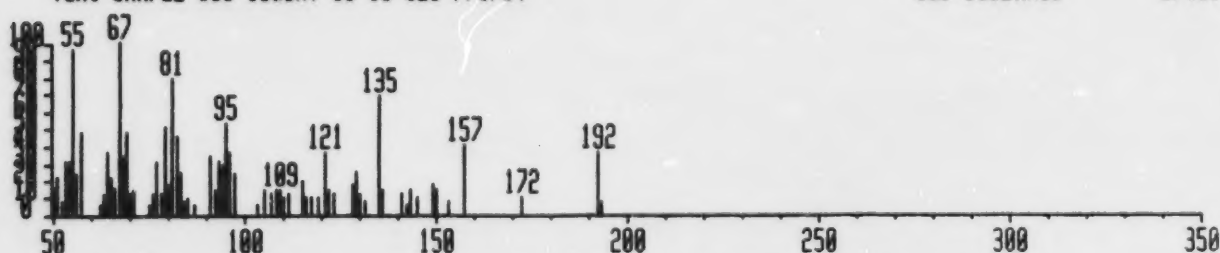
R90#582* x1 Bgd=374 6-JUL-84 10:29:0:11:48 12250 EI+
BpM=55 I=5.0mv Hm=207 TIC=689000 Acnt:GUELPH Sys:350E HMR: 33000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 55.851



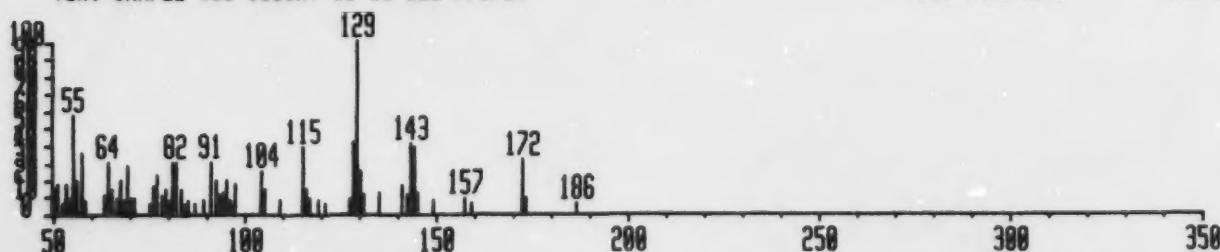
R90#589* x1 Bgd=374 6-JUL-84 10:29:0:11:56 12250 EI+
BpM=92 I=17mv Hm=108 TIC=836000 Acnt:GUELPH Sys:350E HMR: 116000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 92.067



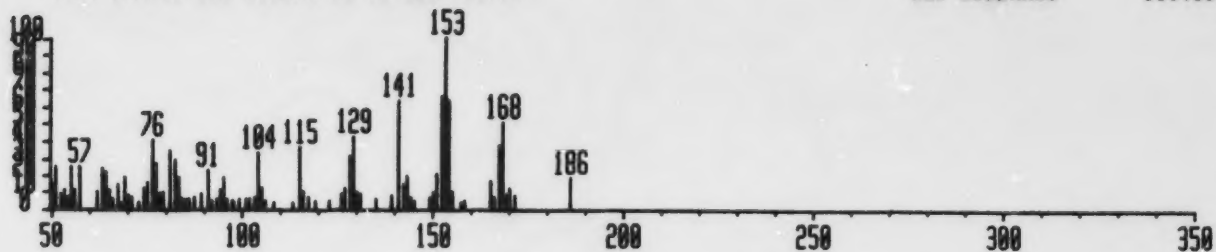
R90#591* x1 Bgd=374 6-JUL-84 10:29:0:11:59 12250 EI+
BpM=67 I=8.1mv Hm=193 TIC=839000 Acnt:GUELPH Sys:350E HMR: 5300
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 67.06



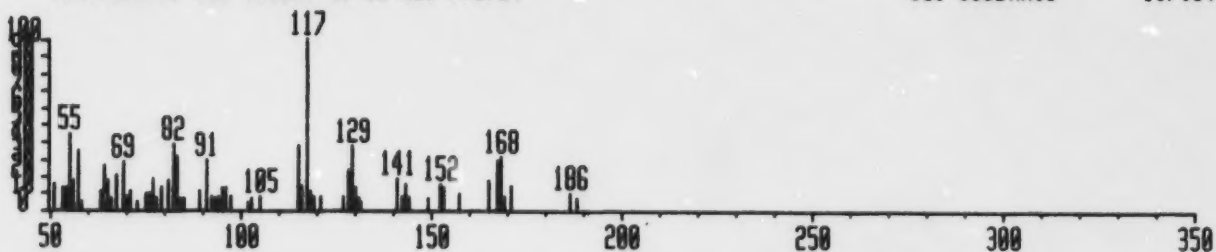
R90#597* x1 Bgd=374 6-JUL-84 10:29:0:12:06 12250 EI+
BpM=129 I=8.9mv Hm=106 TIC=641000 Acnt:GUELPH Sys:350E HMR: 5800
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 129.25



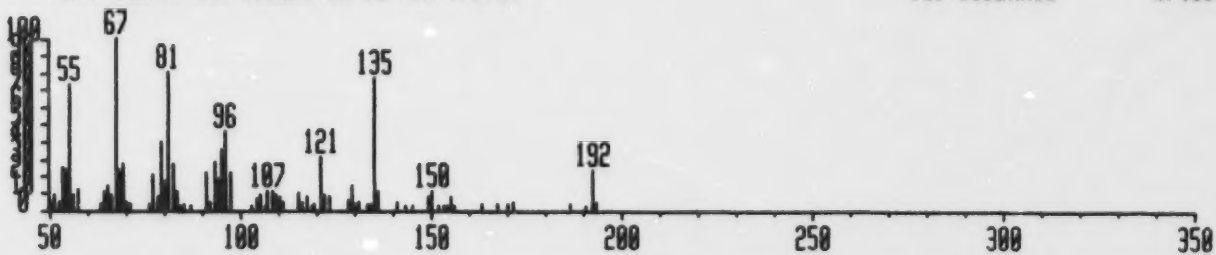
R901602+ x1 Bgd=374 6-JUL-84 10:29:0:12:12 12250 EI+
BpM=153 I=13mv Hm=186 TIC=1240000 Acnt:GUELPH Sys:350E HMR: 91000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 153.069



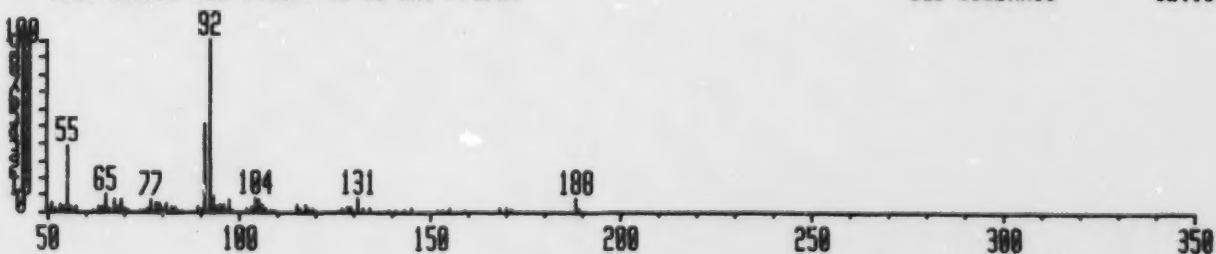
R901600+ x1 Bgd=374 6-JUL-84 10:29:0:12:19 12250 EI+
BpM=117 I=10mv Hm=188 TIC=661000 Acnt:GUELPH Sys:350E HMR: 66000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 117.047



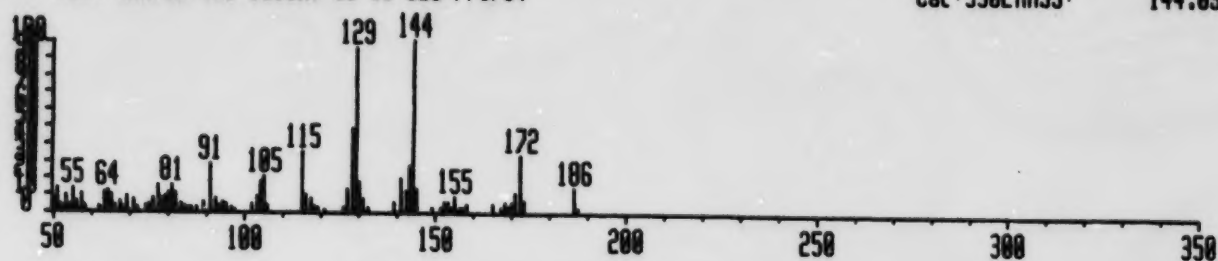
R901617+ x1 Bgd=374 6-JUL-84 10:29:0:12:30 12250 EI+
BpM=67 I=26mv Hm=193 TIC=1059000 Acnt:GUELPH Sys:350E HMR: 174000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 67.059



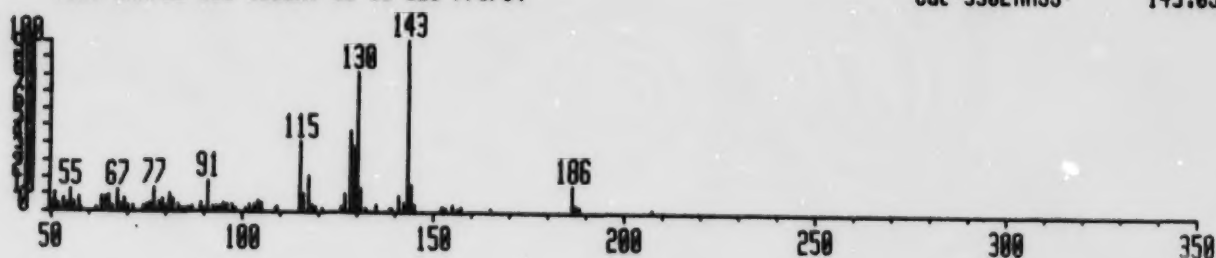
R901623+ x1 Bgd=374 6-JUL-84 10:29:0:12:37 12250 EI+
BpM=92 I=150mv Hm=189 TIC=3441000 Acnt:GUELPH Sys:350E HMR: 904000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 92.151



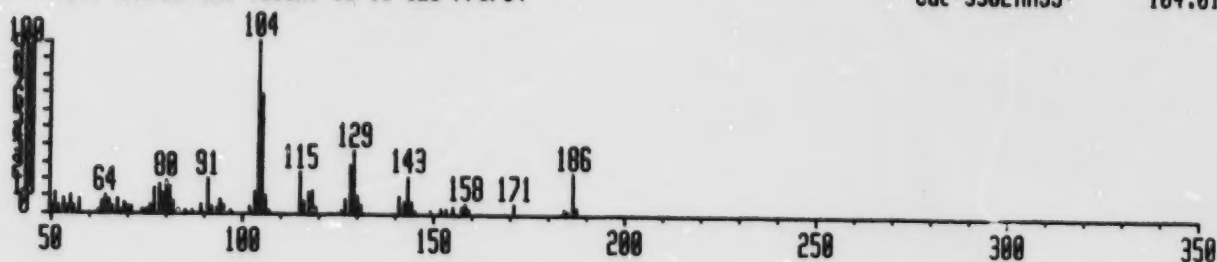
R90#627+ x1 Bgd=374 6-JUL-84 10:29:0:12:42 12250 EI+
 BpM=144 I=32mv Hm=187 TIC=1849000 Acnt:GUELPH Sys:350E HMR: 214000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 144.095



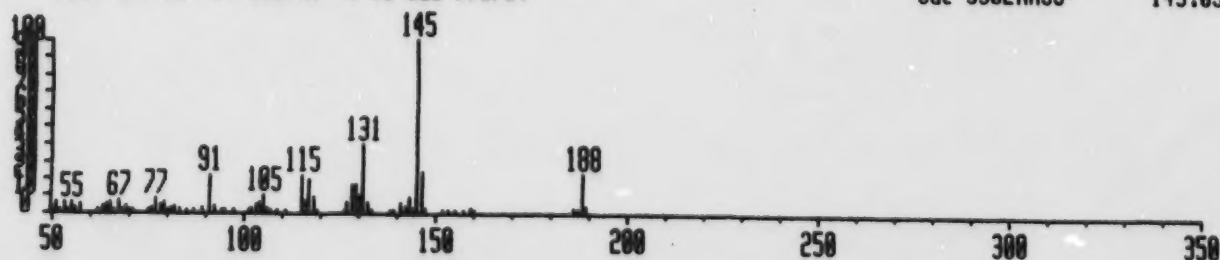
R90#634+ x1 Bgd=374 6-JUL-84 10:29:0:12:51 12250 EI+
 BpM=143 I=45mv Hm=207 TIC=1971000 Acnt:GUELPH Sys:350E HMR: 301000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 143.090



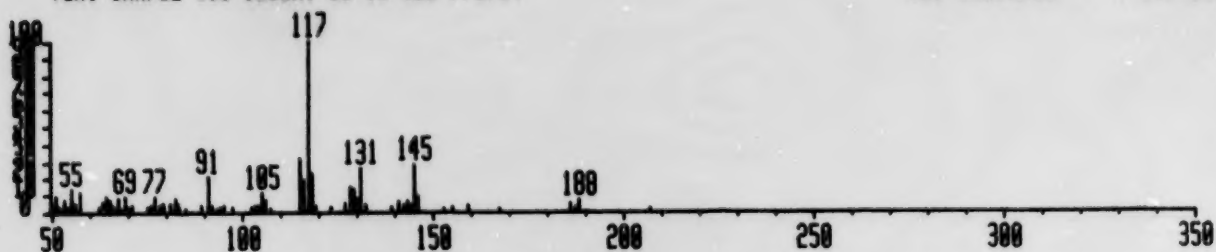
R90#641+ x1 Bgd=374 6-JUL-84 10:29:0:12:59 12250 EI+
 BpM=104 I=39mv Hm=187 TIC=1733000 Acnt:GUELPH Sys:350E HMR: 260000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 104.011



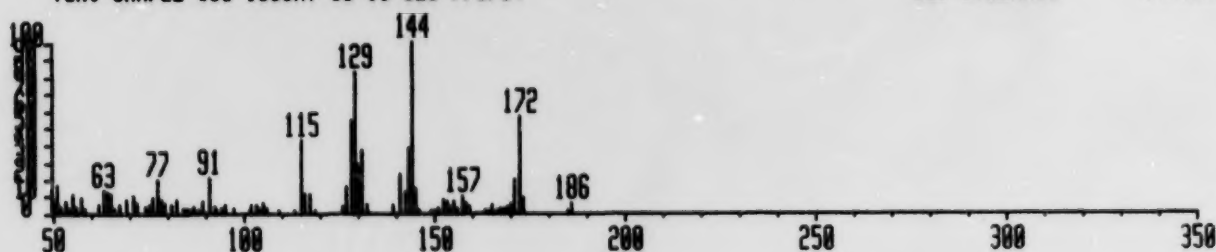
R90#648+ x1 Bgd=374 6-JUL-84 10:29:0:13:07 12250 EI+
 BpM=145 I=83mv Hm=189 TIC=2557000 Acnt:GUELPH Sys:350E HMR: 546000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 145.090



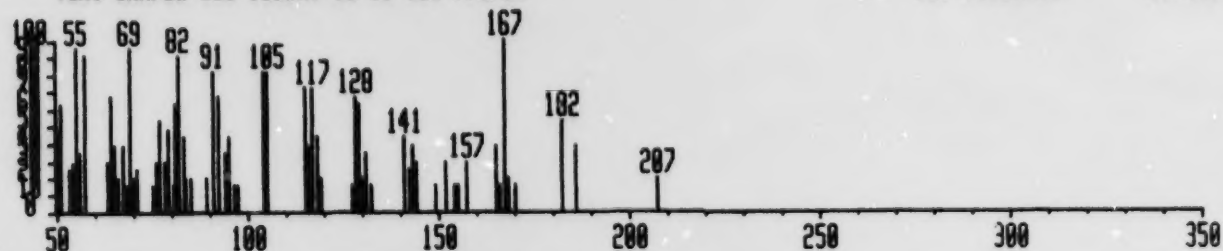
R90#652* x1 Bgd=374 6-JUL-84 10:29:0:13:12 12250 EI+
BpM=117 I=32mv Hm=206 TIC=1105000 Acnt:GUELPH Sys:350E HMR: 213000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 117.052



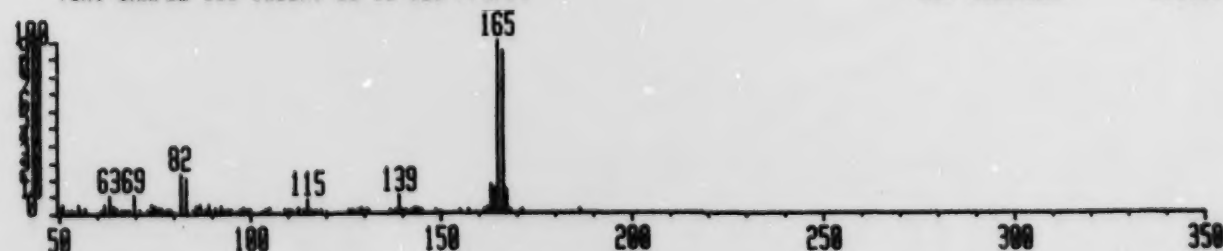
R90#650* x1 Bgd=374 6-JUL-84 10:29:0:13:20 12250 EI+
BpM=144 I=43mv Hm=106 TIC=2514000 Acnt:GUELPH Sys:350E HMR: 203000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 144.093



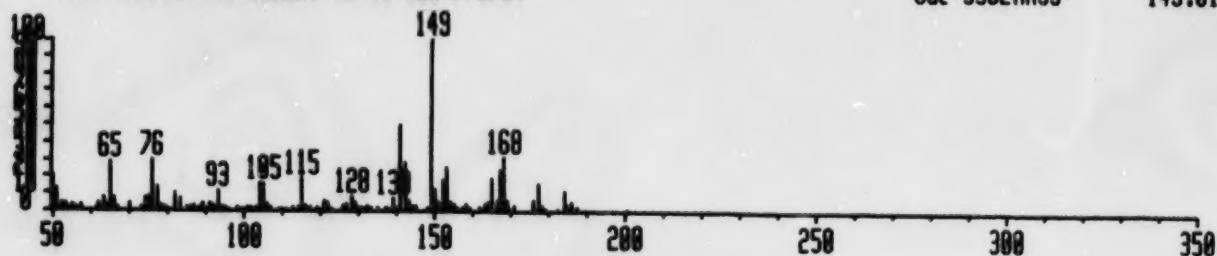
R90#661* x1 Bgd=374 6-JUL-84 10:29:0:13:23 12250 EI+
BpM=167 I=3.2mv Hm=207 TIC=537000 Acnt:GUELPH Sys:350E HMR: 21000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 167.007



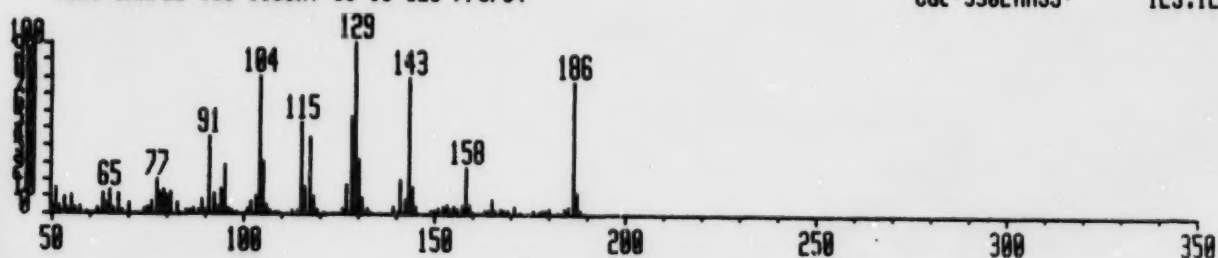
R90#667* x1 Bgd=374 6-JUL-84 10:29:0:13:30 12250 EI+
BpM=165 I=107mv Hm=106 TIC=3014000 Acnt:GUELPH Sys:350E HMR: 70500
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 165.167



R90#675+ x1 Bgd=374 6-JUL-84 10:29:0:13:40 12250 EI+
 BpM=149 I=153mv Hm=200 TIC=6921000 Acnt:GUELPH Sys:350E HMR: 1005000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 149.019



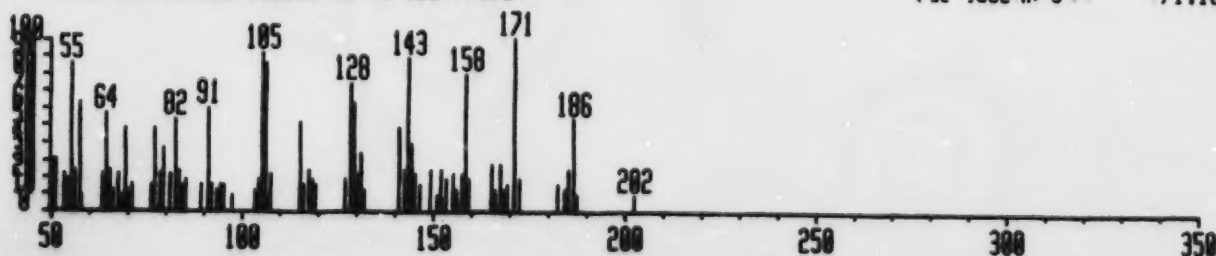
R90#682+ x1 Bgd=677 6-JUL-84 10:29:0:13:49 12250 EI+
 BpM=129 I=122mv Hm=180 TIC=8550000 Acnt:GUELPH Sys:350E HMR: 804000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 129.129



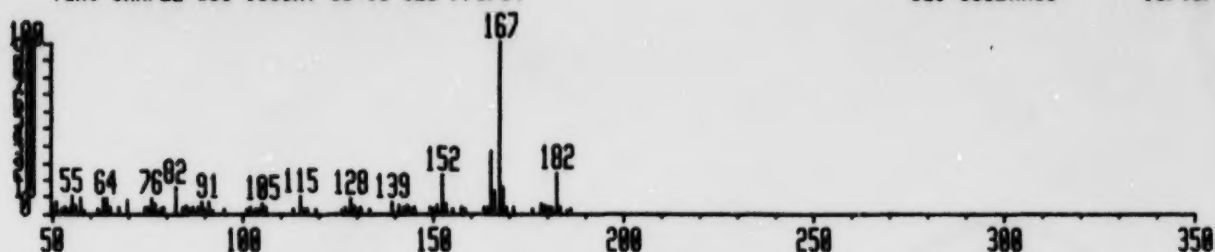
R90#686+ x1 Bgd=677 6-JUL-84 10:29:0:13:53 12250 EI+
 BpM=171 I=42mv Hm=187 TIC=1070000 Acnt:GUELPH Sys:350E HMR: 270000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 171.104



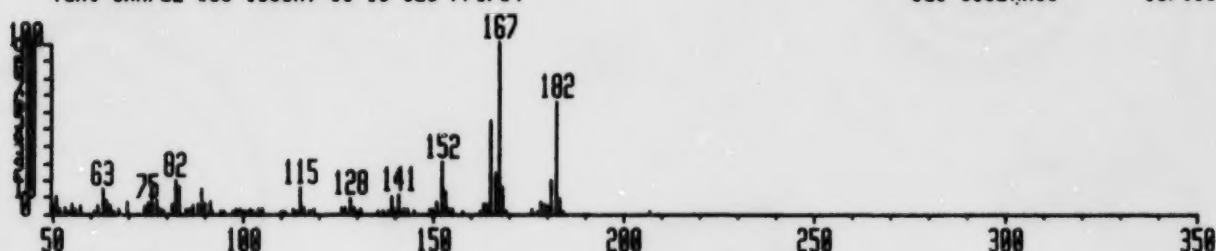
R90#692+ x1 Bgd=677 6-JUL-84 10:29:0:14:01 12250 EI+
 BpM=171 I=5.2mv Hm=202 TIC=764000 Acnt:GUELPH Sys:350E HMR: 34000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 171.100



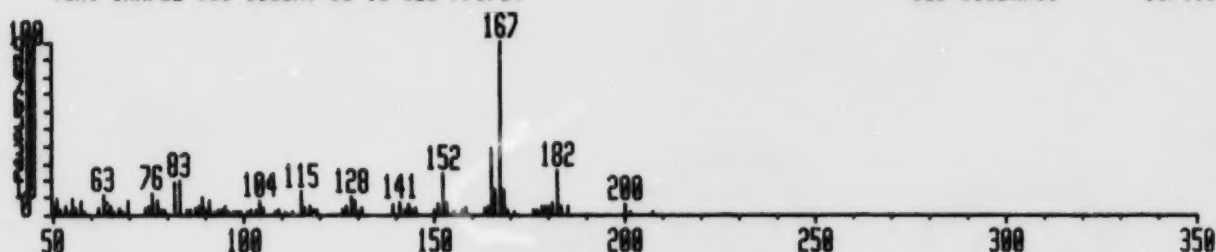
R90#697* x1 Bgd=677 6-JUL-84 10:29:0:14:07 12250 EI+
BpM=167 I=33nv Hm=186 TIC=1115000 Acnt:GUELPH Sys:350E HMR: 222000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 167.070



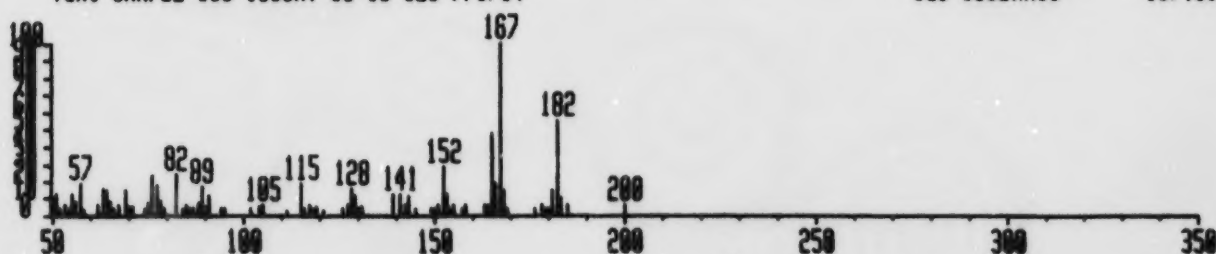
R90#703* x1 Bgd=677 6-JUL-84 10:29:0:14:14 12250 EI+
BpM=167 I=65nv Hm=206 TIC=2046000 Acnt:GUELPH Sys:350E HMR: 431000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 167.105



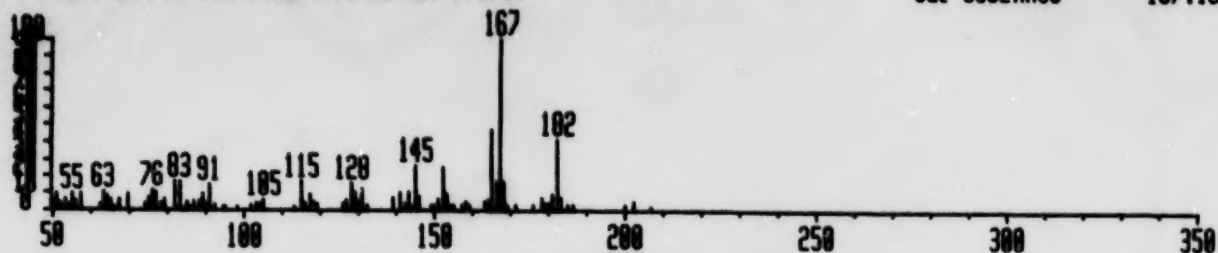
R90#709* x1 Bgd=677 6-JUL-84 10:29:0:14:21 12250 EI+
BpM=167 I=48nv Hm=207 TIC=1025000 Acnt:GUELPH Sys:350E HMR: 317000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 167.16



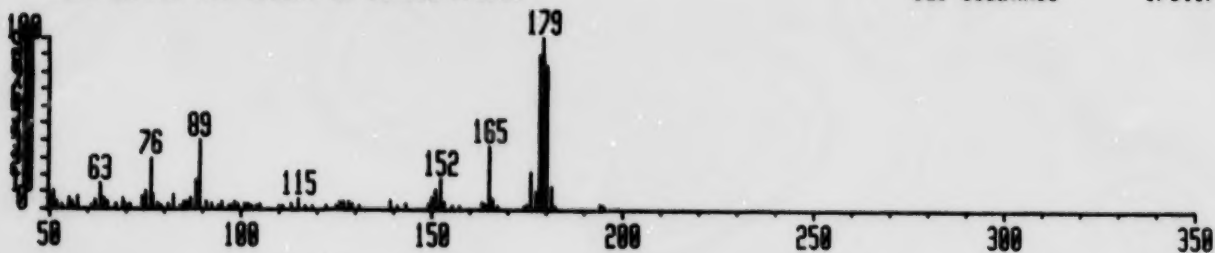
R90#711* x1 Bgd=677 6-JUL-84 10:29:0:14:24 12250 EI+
BpM=167 I=21nv Hm=200 TIC=1121000 Acnt:GUELPH Sys:350E HMR: 142000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 167.00



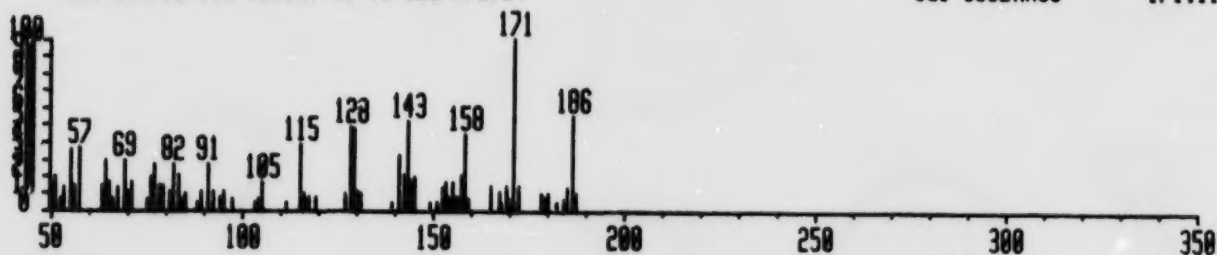
R900714* x1 Bgd=677 6-JUL-84 10:29:0:14:27 12250 EI+
BpM=167 I=40mv Hm=206 TIC=1030000 Acnt:GUELPH Sys:350E HMR: 266000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 167.165



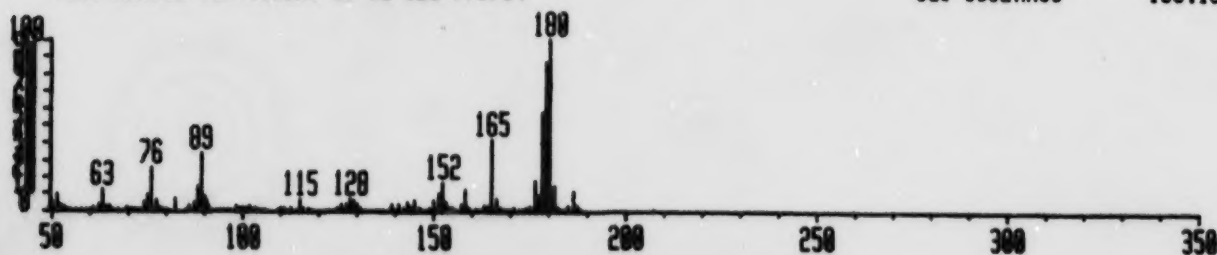
R900727* x1 Bgd=677 6-JUL-84 10:29:0:14:43 12250 EI+
BpM=179 I=51mv Hm=195 TIC=2272000 Acnt:GUELPH Sys:350E HMR: 335000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 179.170



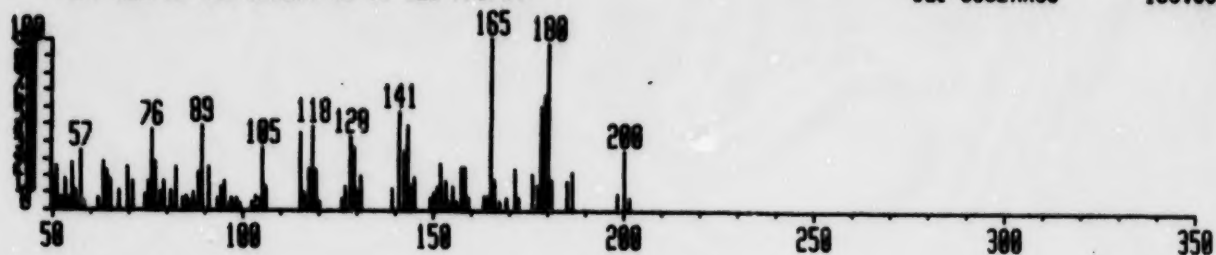
R900730* x1 Bgd=677 6-JUL-84 10:29:0:14:47 12250 EI+
BpM=171 I=9.0mv Hm=187 TIC=832000 Acnt:GUELPH Sys:350E HMR: 64000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 171.11



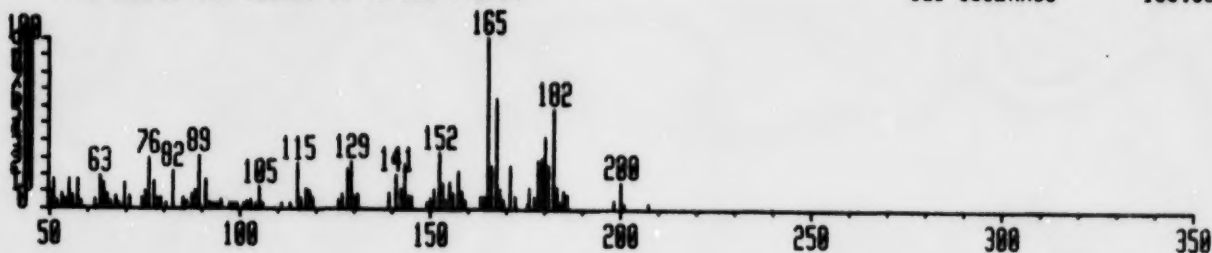
R900736* x1 Bgd=732 6-JUL-84 10:29:0:14:54 12250 EI+
BpM=180 I=2.0v Hm=207 TIC=84314000 Acnt:GUELPH Sys:350E HMR: 1336000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 180.180



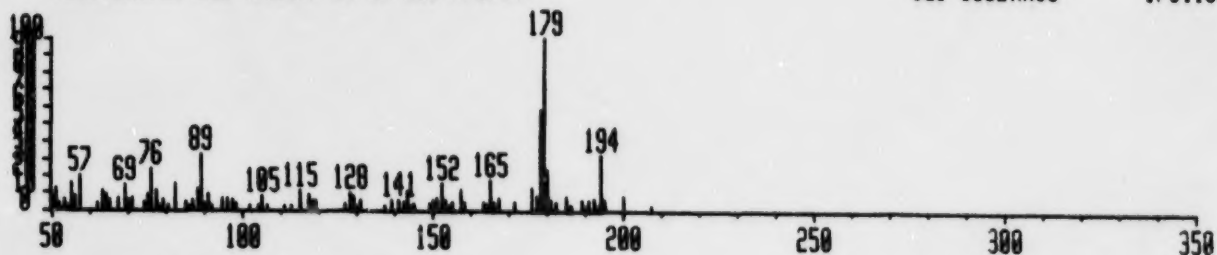
R900740 x1 Bgd=732 6-JUL-84 10:29:0:14:59 12250 EI+
 BpM=165 I=13mv Hn=201 TIC=1540000 Acnt:GUELPH Sys:350E HMR: 05000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 165.060



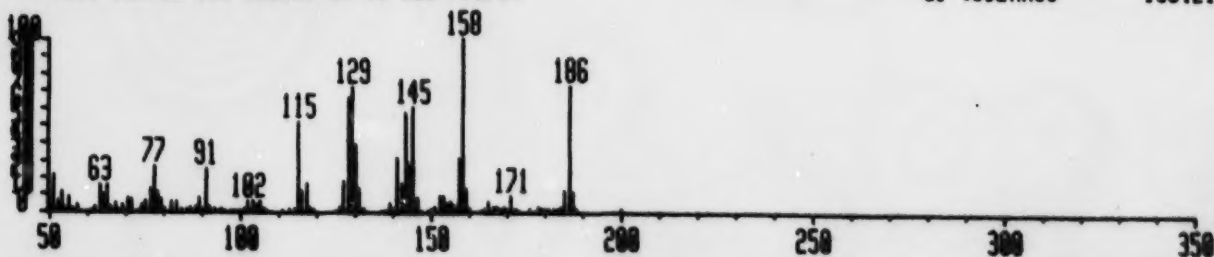
R900744 x1 Bgd=732 6-JUL-84 10:29:0:15:03 12250 EI+
 BpM=165 I=25mv Hn=207 TIC=2013000 Acnt:GUELPH Sys:350E HMR: 167000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 165.050



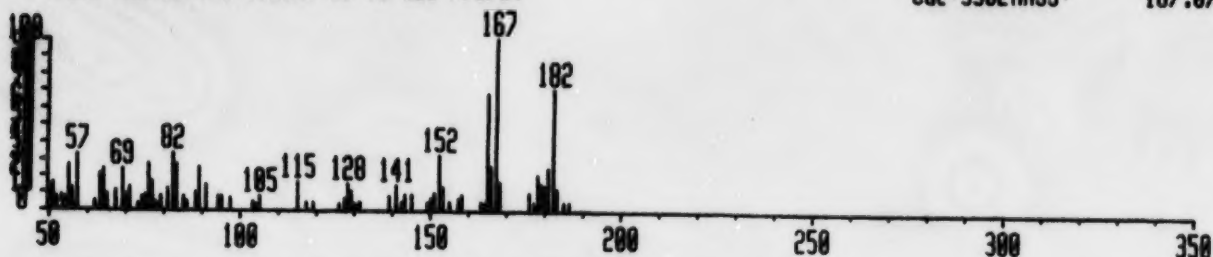
R900749 x1 Bgd=732 6-JUL-84 10:29:0:15:09 12250 EI+
 BpM=179 I=25mv Hn=207 TIC=1307000 Acnt:GUELPH Sys:350E HMR: 168000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 179.160



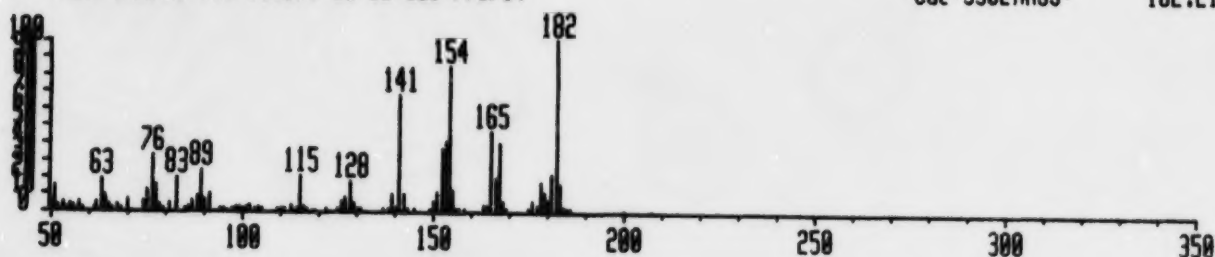
R900754 x1 Bgd=751 6-JUL-84 10:29:0:15:16 12250 EI+
 BpM=150 I=244mv Hn=200 TIC=16942000 Acnt:GUELPH Sys:350E HMR: 1601000
 Text: SAMPLE 090 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 150.210



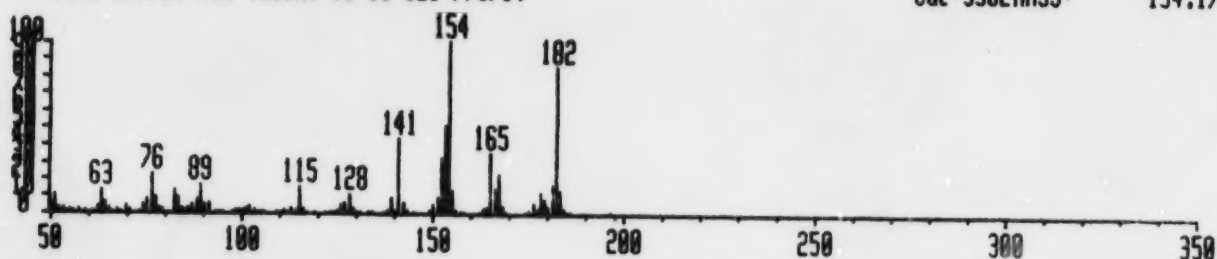
R901761+ x1 Bgd=751 6-JUL-84 10:29:0:15:24 12250 EI+
 BpM=167 I=13mv Hm=106 TIC=910000 Acnt:GUELPH Sys:350E HMR: 06000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 167.070



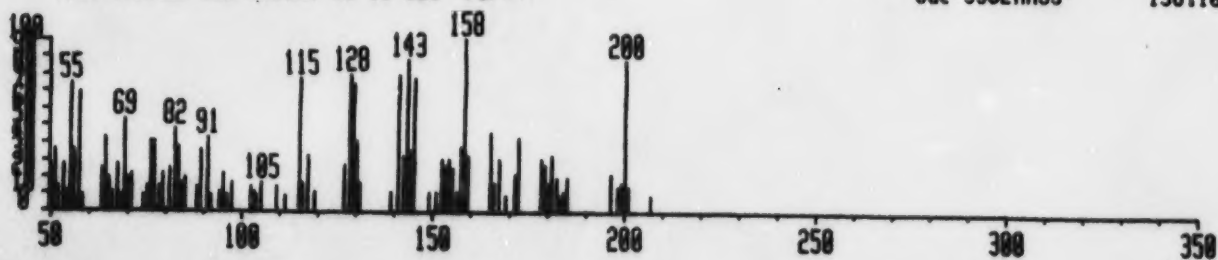
R901771+ x1 Bgd=751 6-JUL-84 10:29:0:15:36 12250 EI+
 BpM=182 I=90mv Hm=207 TIC=5035000 Acnt:GUELPH Sys:350E HMR: 640000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 182.213



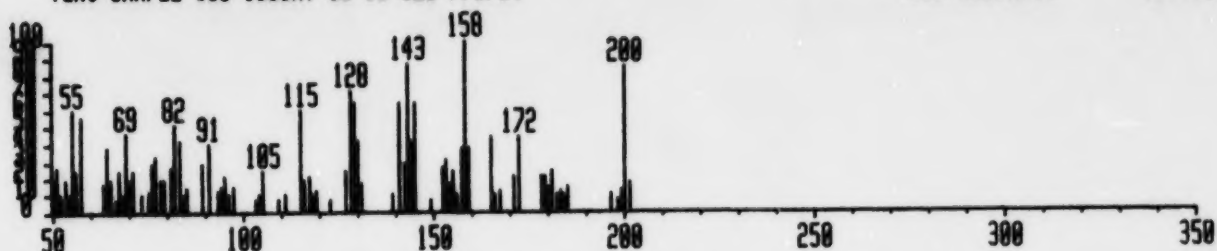
R901775+ x1 Bgd=772 6-JUL-84 10:29:0:15:41 12250 EI+
 BpM=154 I=523mv Hm=196 TIC=24330000 Acnt:GUELPH Sys:350E HMR: 3420000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 154.173



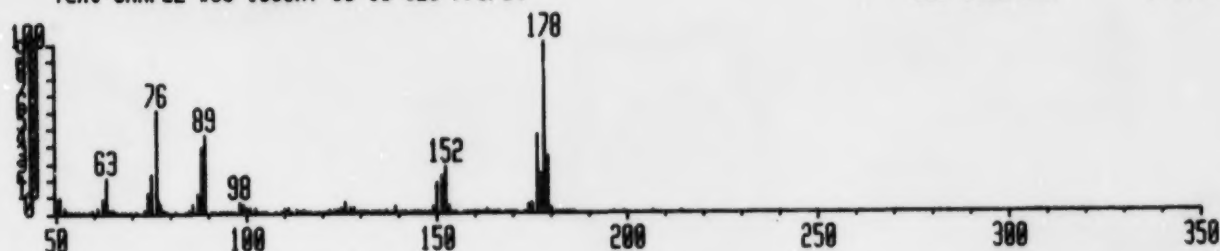
R901781+ x1 Bgd=772 6-JUL-84 10:29:0:15:40 12250 EI+
 BpM=158 I=5.0mv Hm=206 TIC=940000 Acnt:GUELPH Sys:350E HMR: 30000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 158.106



R90#785* x1 Bgd=772 6-JUL-84 10:29:0:15:53 12250 EI+
BpM=150 I=6.7mv Hm=201 TIC=942000 Acnt:GUELPH Sys:350E HMR: 44000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 158.103



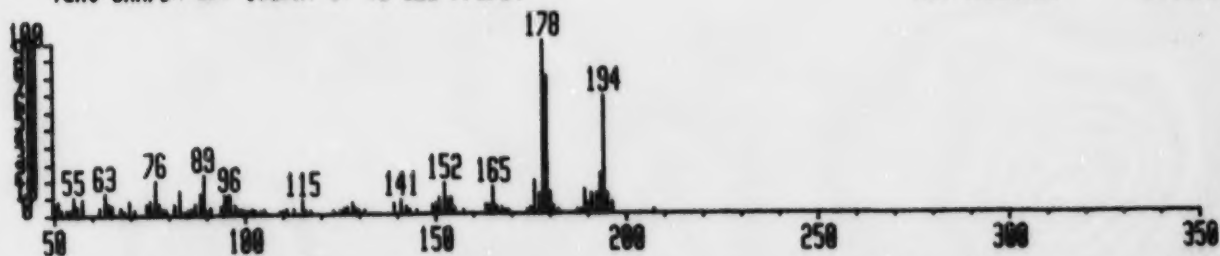
R90#792* x1 Bgd=786 6-JUL-84 10:29:0:16:01 12250 EI+
BpM=178 I=10v Hm=214 TIC=300976992 Acnt:GUELPH Sys:350E HMR: 65534000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 170.192



R90#795* x1 Bgd=786 6-JUL-84 10:29:0:16:05 12250 EI+
BpM=178 I=140mv Hm=214 TIC=3334000 Acnt:GUELPH Sys:350E HMR: 971000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 170.171



R90#804* x1 Bgd=786 6-JUL-84 10:29:0:16:16 12250 EI+
BpM=178 I=53mv Hm=207 TIC=2631000 Acnt:GUELPH Sys:350E HMR: 350000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 170.15



145

R900817* x1 Bgd=786 6-JUL-84 10:29:0:16:32 12250 EI+

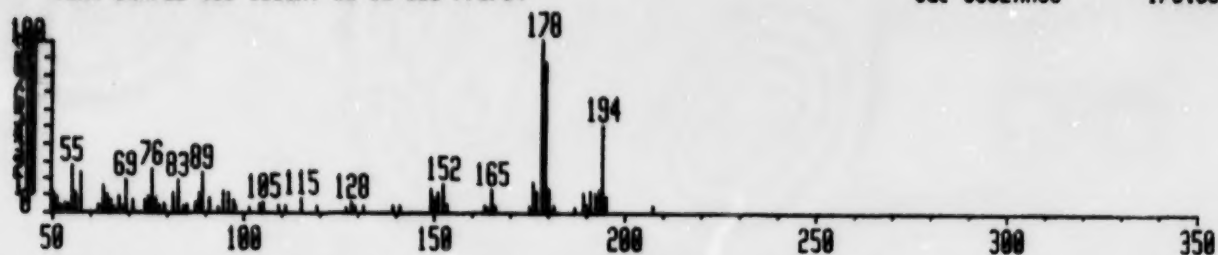
BpM=170 I=21mv Hm=207 TIC=1104000

Acnt: GUELPH

Sys: 350E HMR: 130000

Text: SAMPLE 090 1600MV 50-10-320 7/6/84

Cal: 350EMASS: 170.067



R900831* x1 Bgd=786 6-JUL-84 10:29:0:16:40 12250 EI+

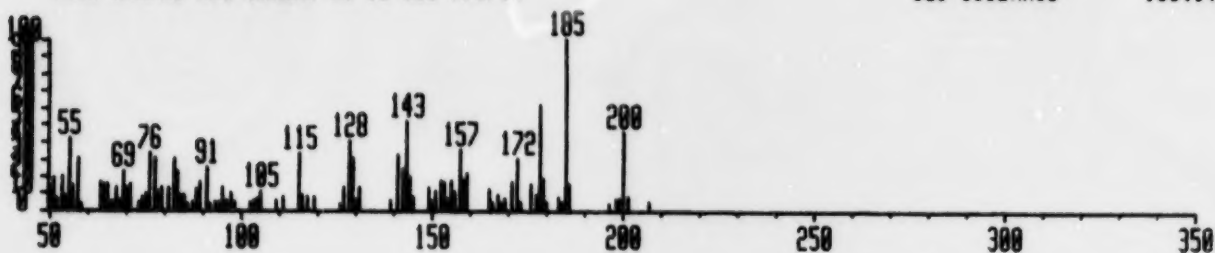
BpM=185 I=14mv Hm=206 TIC=1393000

Acnt: GUELPH

Sys: 350E HMR: 95000

Text: SAMPLE 090 1600MV 50-10-320 7/6/84

Cal: 350EMASS: 185.140



R900838* x1 Bgd=786 6-JUL-84 10:29:0:16:57 12250 EI+

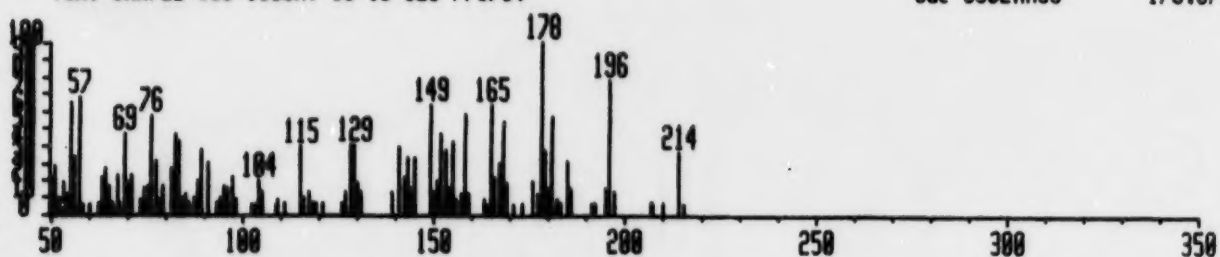
BpM=170 I=9.5mv Hm=215 TIC=1469000

Acnt: GUELPH

Sys: 350E HMR: 62000

Text: SAMPLE 090 1600MV 50-10-320 7/6/84

Cal: 350EMASS: 170.070



R900851* x1 Bgd=786 6-JUL-84 10:29:0:17:13 12250 EI+

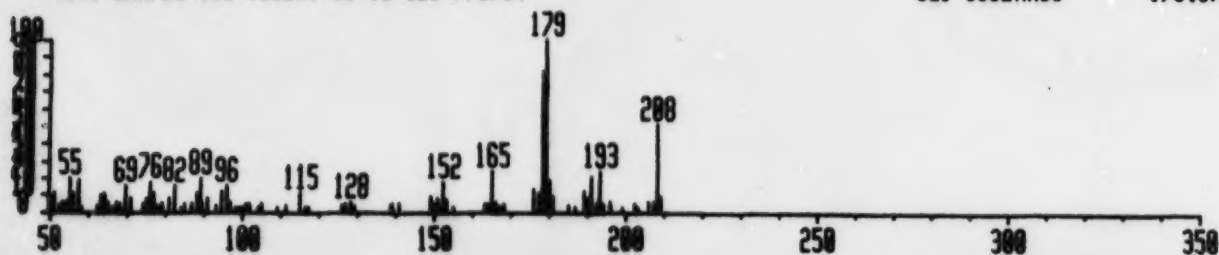
BpM=179 I=24mv Hm=209 TIC=1349000

Acnt: GUELPH

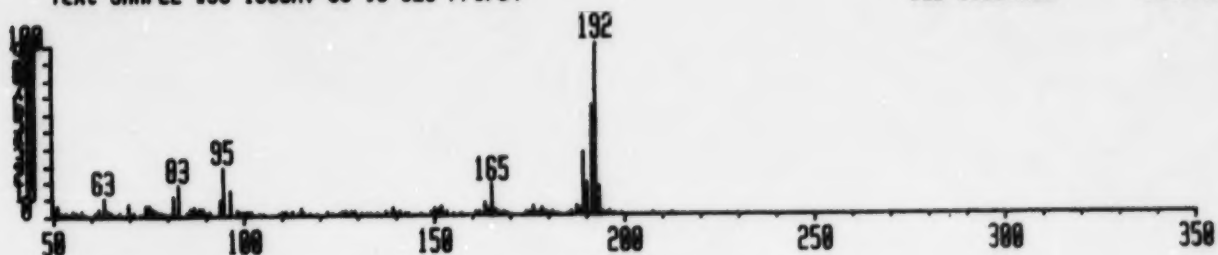
Sys: 350E HMR: 150000

Text: SAMPLE 090 1600MV 50-10-320 7/6/84

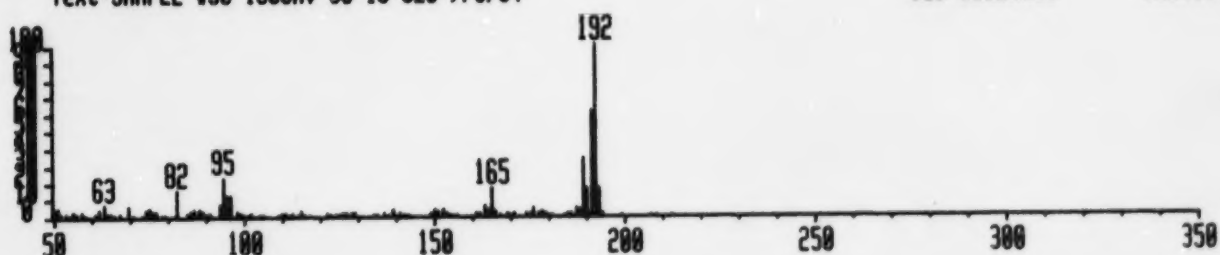
Cal: 350EMASS: 179.070



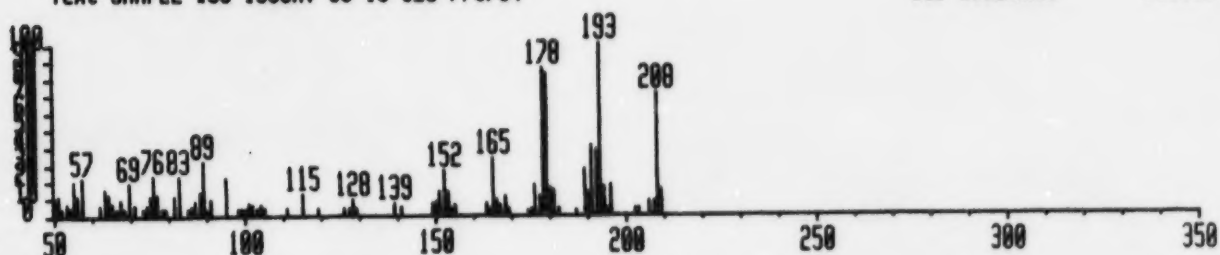
R900855* x1 Bgd=786 6-JUL-84 10:29:0:17:17 12250 EI+
 BpM=192 I=253mv Hm=212 TIC=7961000 Acnt:GUELPH Sys:350E HMR: 1661000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 192.199



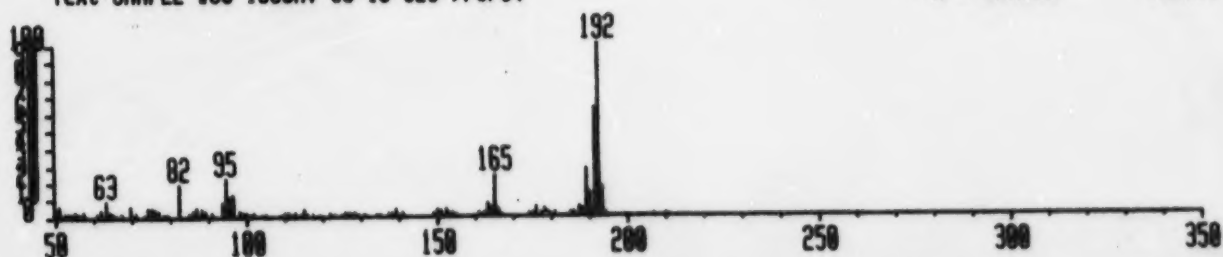
R900850* x1 Bgd=786 6-JUL-84 10:29:0:17:21 12250 EI+
 BpM=192 I=300mv Hm=212 TIC=8010000 Acnt:GUELPH Sys:350E HMR: 2024000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 192.193



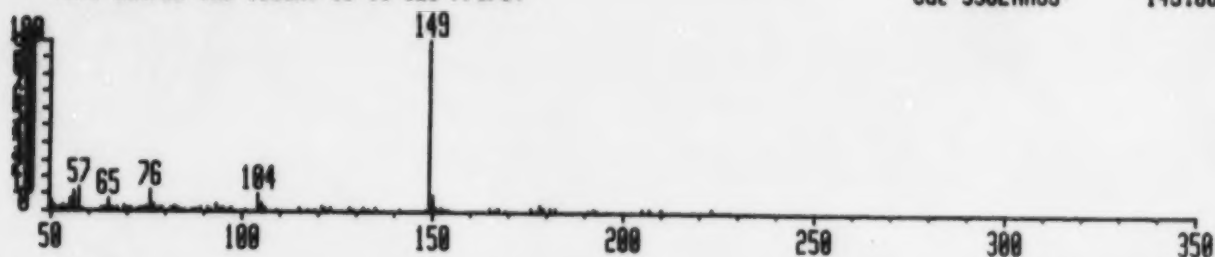
R900861* x1 Bgd=786 6-JUL-84 10:29:0:17:25 12250 EI+
 BpM=193 I=21mv Hm=209 TIC=1609000 Acnt:GUELPH Sys:350E HMR: 139000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 193.191



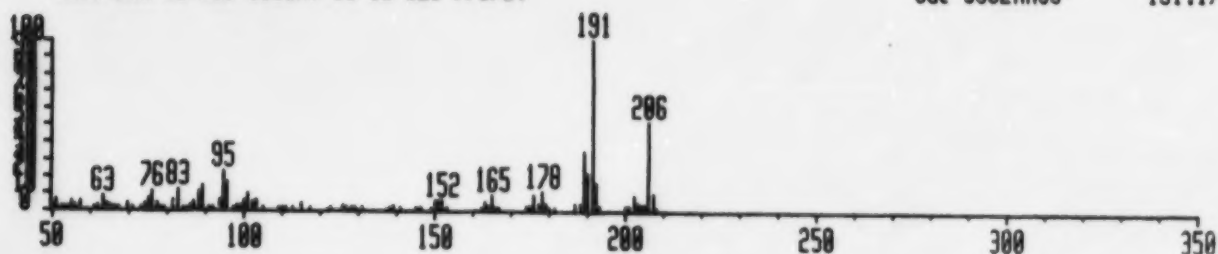
R900869* x1 Bgd=786 6-JUL-84 10:29:0:17:34 12250 EI+
 BpM=192 I=106mv Hm=210 TIC=5592000 Acnt:GUELPH Sys:350E HMR: 122500
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 192.19



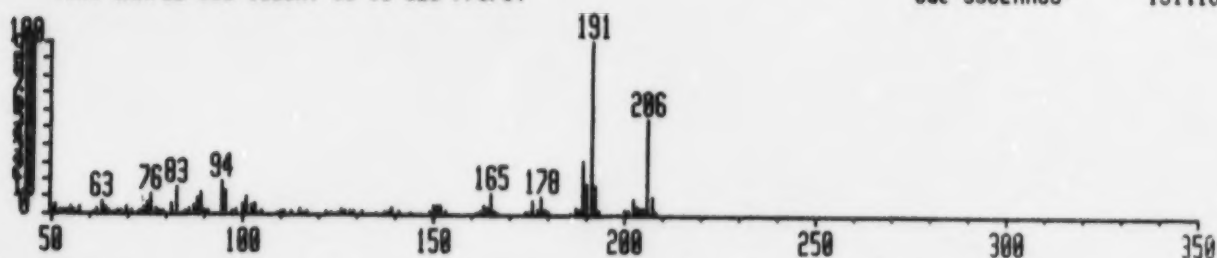
R900880 x1 Bgd=706 6-JUL-84 10:29:0:17:57 12250 EI+
BpM=149 I=146mv Hm=223 TIC=2347000 Acnt:GUELPH Sys:350E HMR: 961000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 149.800



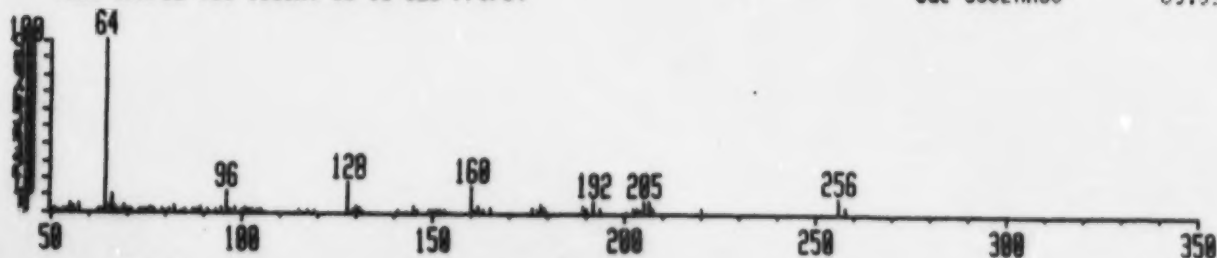
R900906 x1 Bgd=706 6-JUL-84 10:29:0:18:19 12250 EI+
BpM=191 I=89mv Hm=200 TIC=3240000 Acnt:GUELPH Sys:350E HMR: 589000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 191.170



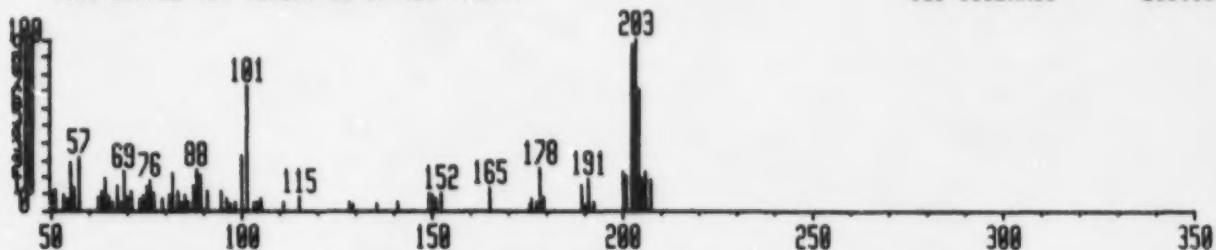
R900915 x1 Bgd=706 6-JUL-84 10:29:0:18:30 12250 EI+
BpM=191 I=127mv Hm=200 TIC=4230000 Acnt:GUELPH Sys:350E HMR: 83500
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 191.18



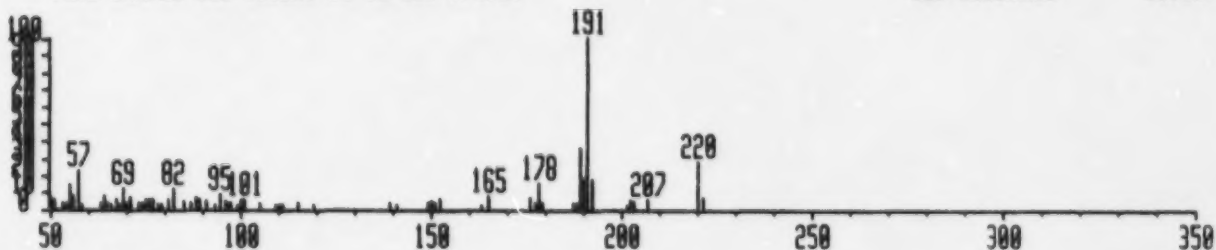
R900933 x1 Bgd=706 6-JUL-84 10:29:0:18:52 12250 EI+
BpM=64 I=94mv Hm=257 TIC=1026000 Acnt:GUELPH Sys:350E HMR: 62000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 63.95



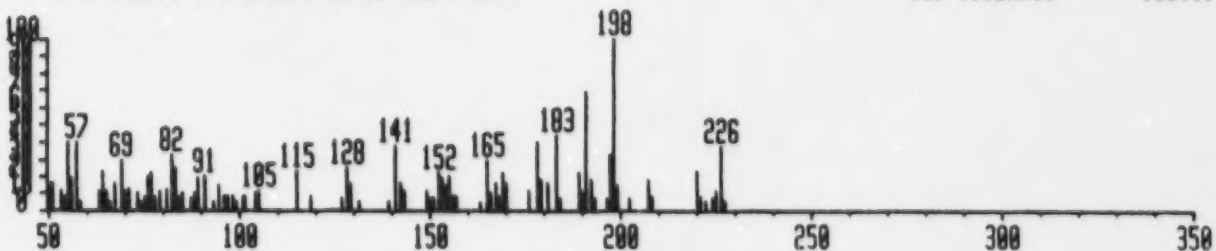
R90#941* x1 Bgd=786 6-JUL-84 10:29:0:19:01 12250 EI+
 BpM=203 I=13mv Hm=207 TIC=912000 Acnt:GUELPH Sys:350E HMR: 85000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 203.164



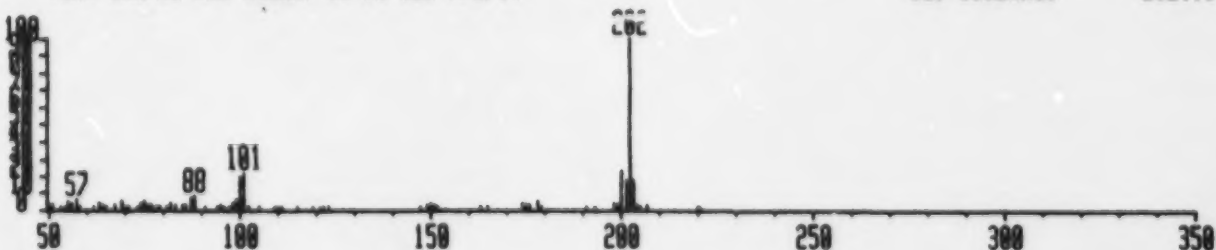
R90#955* x1 Bgd=786 6-JUL-84 10:29:0:19:10 12250 EI+
 BpM=191 I=25mv Hm=221 TIC=837000 Acnt:GUELPH Sys:350E HMR: 166000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 191.071



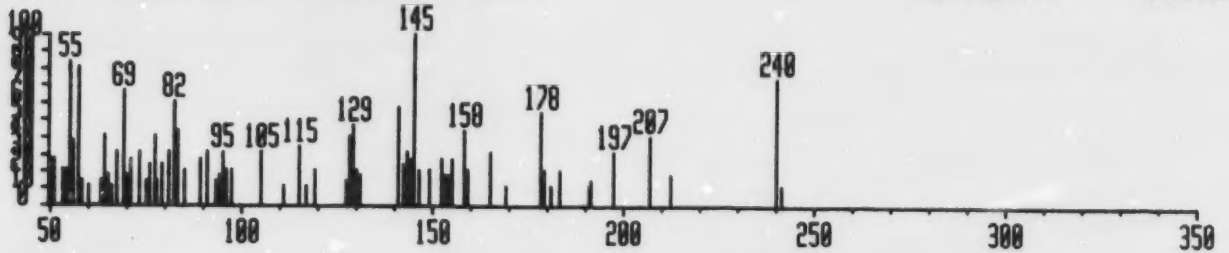
R90#965* x1 Bgd=786 6-JUL-84 10:29:0:19:30 12250 EI+
 BpM=198 I=10mv Hm=227 TIC=965000 Acnt:GUELPH Sys:350E HMR: 6700
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 198.13



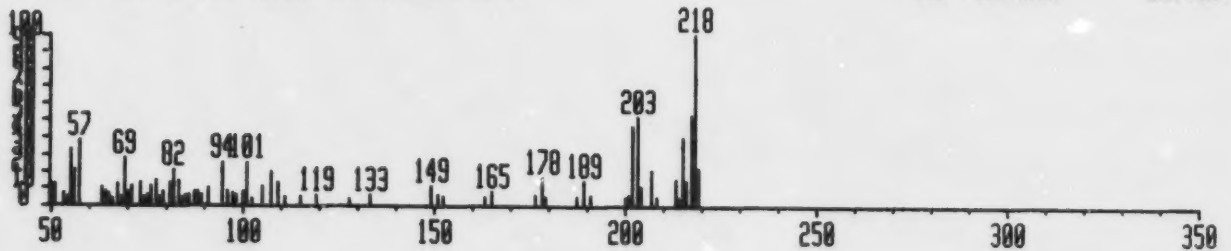
R90#972* x1 Bgd=786 6-JUL-84 10:29:0:19:39 12250 EI+
 BpM=202 I=71mv Hm=228 TIC=1583000 Acnt:GUELPH Sys:350E HMR: 47000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 202.15



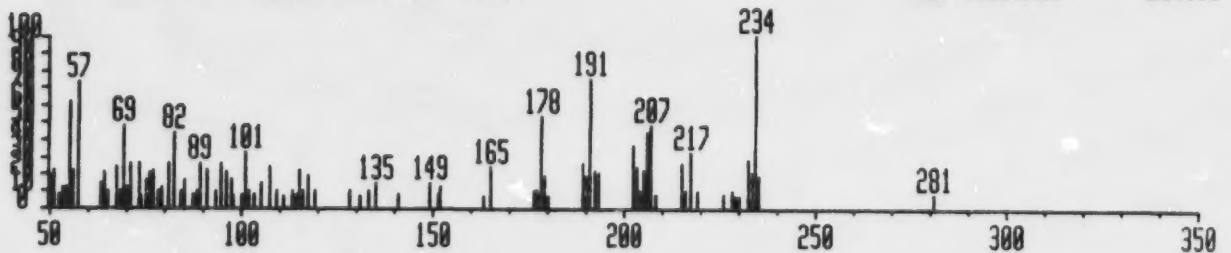
R90#990* x1 Bgd=786 6-JUL-84 10:29:0:20:10 12250 EI+
 BpM=145 I=4.6mv Hm=241 TIC=590000 Acnt:GUELPH Sys:350E HMR: 30000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 145.101



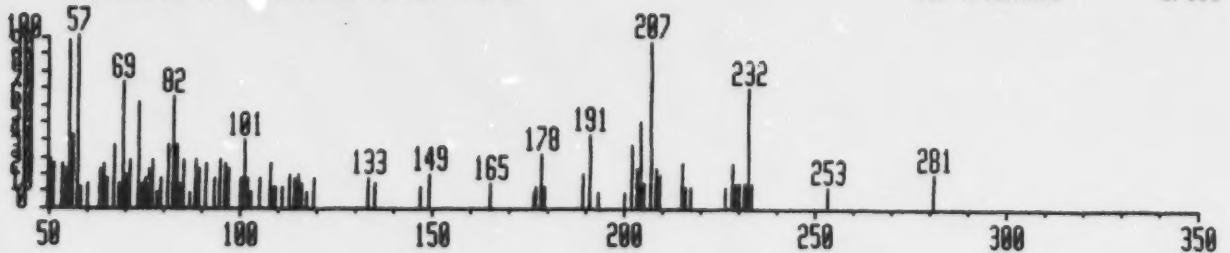
R90#1037* x1 Bgd=786 6-JUL-84 10:29:0:20:57 12250 EI+
 BpM=218 I=13mv Hm=219 TIC=876000 Acnt:GUELPH Sys:350E HMR: 89000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 218.001



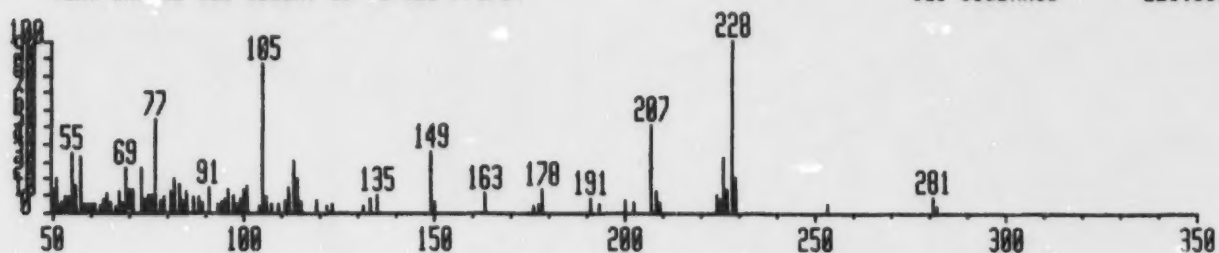
R90#1054* x1 Bgd=786 6-JUL-84 10:29:0:21:10 12250 EI+
 BpM=234 I=7.8mv Hm=200 TIC=903000 Acnt:GUELPH Sys:350E HMR: 5100
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 234.12



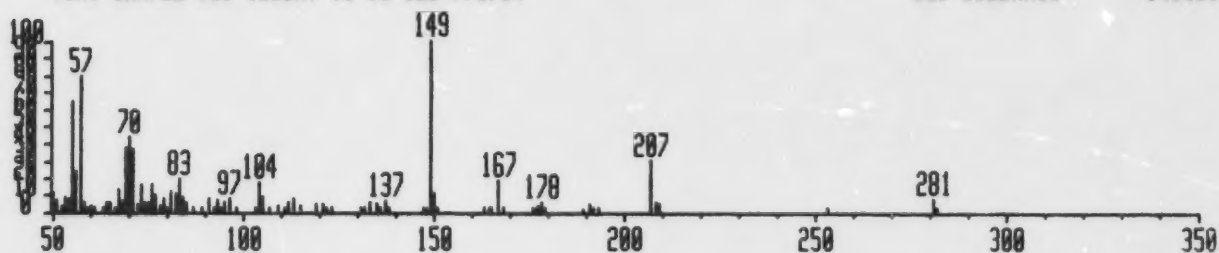
R90#1113* x1 Bgd=786 6-JUL-84 10:29:0:22:29 12250 EI+
 BpM=57 I=5.5mv Hm=200 TIC=755000 Acnt:GUELPH Sys:350E HMR: 3600
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 57.10



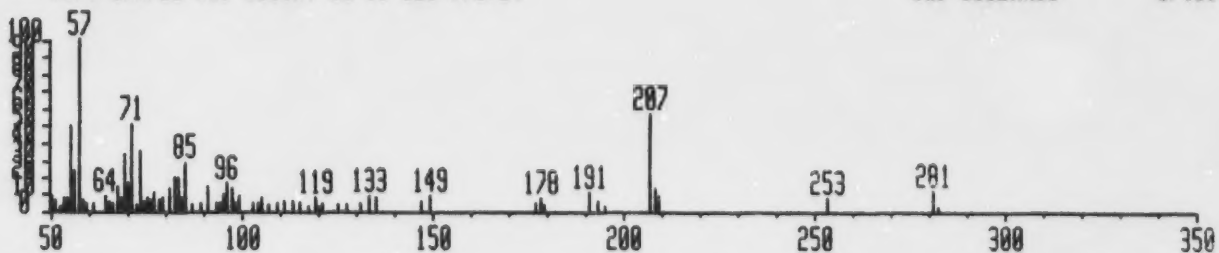
R90#1138* x1 Bgd=786 6-JUL-84 10:29:0:22:59 12250 EI+
 BpM=228 I=15mv Hm=281 TIC=1093000 Acnt:GUELPH Sys:350E HMR: 98800
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350E MASS: 228.055



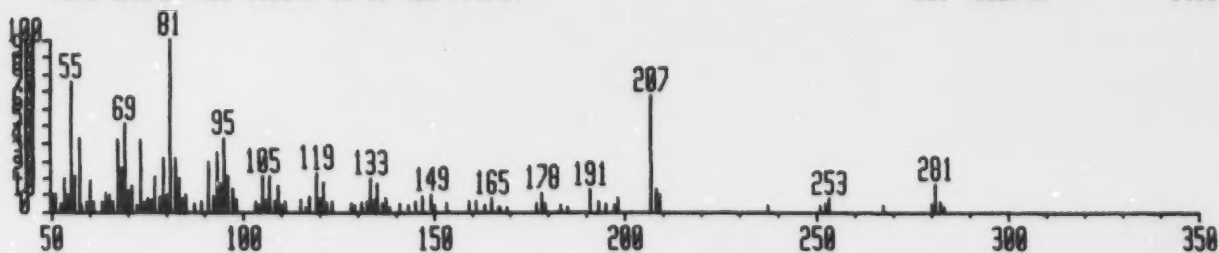
R90#1165* x1 Bgd=786 6-JUL-84 10:29:0:23:32 12250 EI+
 BpM=149 I=35mv Hm=281 TIC=1916000 Acnt:GUELPH Sys:350E HMR: 23200
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350E MASS: 149.001



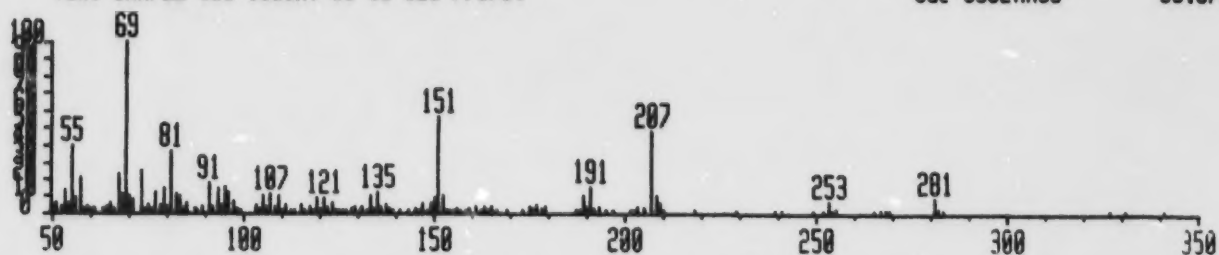
R90#1183* x1 Bgd=786 6-JUL-84 10:29:0:23:54 12250 EI+
 BpM=57 I=19mv Hm=282 TIC=1076000 Acnt:GUELPH Sys:350E HMR: 13000
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350E MASS: 57.00



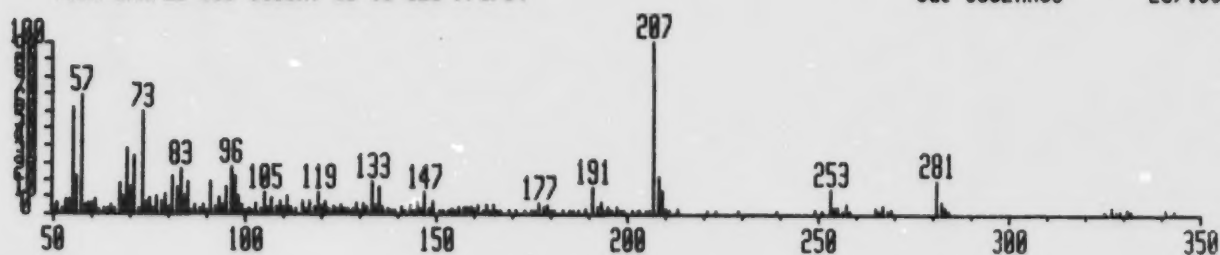
R90#1192* x1 Bgd=786 6-JUL-84 10:29:0:24:04 12250 EI+
 BpM=81 I=10mv Hm=283 TIC=1657000 Acnt:GUELPH Sys:350E HMR: 12200
 Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350E MASS: 81.06



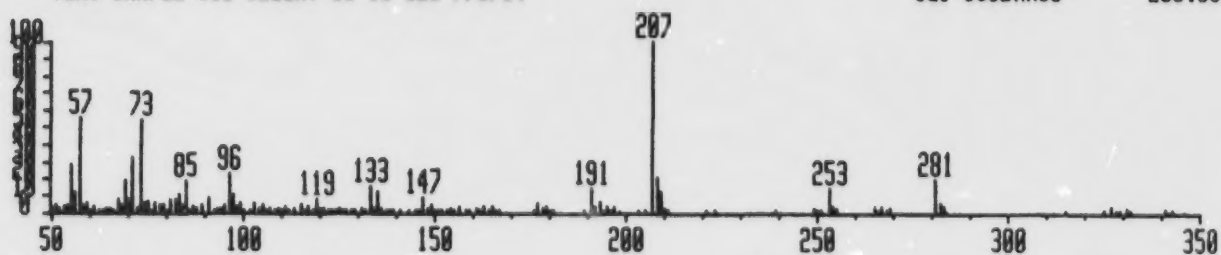
R90#1277* x1 Bgd=786 6-JUL-84 10:29:0:25:47 12250 EI+
BpM=69 I=69mv Hm=340 TIC=3999000 Acnt: GUELPH Sys: 350E HMR: 455000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 69.076



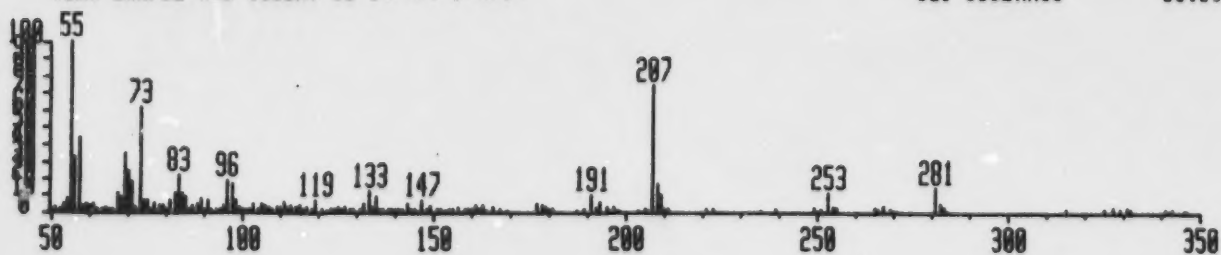
R90#1374* x1 Bgd=786 6-JUL-84 10:29:0:27:44 12250 EI+
BpM=207 I=82mv Hm=343 TIC=6375000 Acnt: GUELPH Sys: 350E HMR: 530000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 207.000



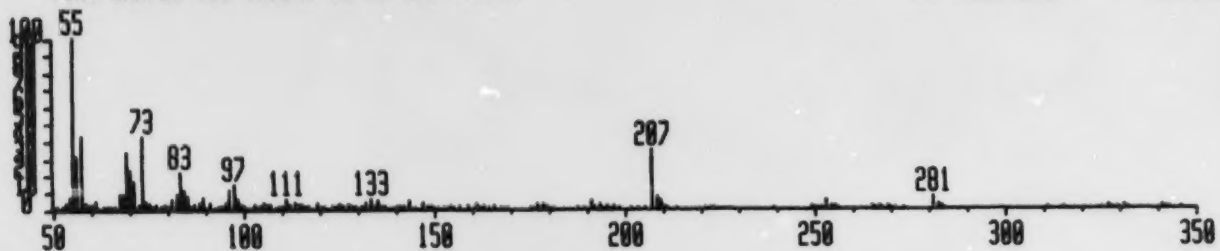
R90#1426* x1 Bgd=786 6-JUL-84 10:29:0:28:47 12250 EI+
BpM=207 I=107mv Hm=345 TIC=5555000 Acnt: GUELPH Sys: 350E HMR: 701000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 206.980



R90#1552* x1 Bgd=786 6-JUL-84 10:29:0:31:19 12250 EI+
BpM=55 I=168mv Hm=346 TIC=9379000 Acnt: GUELPH Sys: 350E HMR: 1107000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal: 350EMASS: 55.05



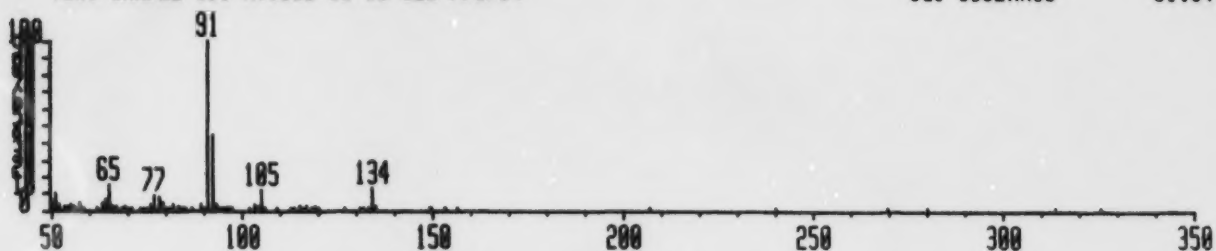
R9001571* x1 Bgd=1566 6-JUL-84 10:29:03:42 12250 EI+
BpM=55 I=379mv Hm=346 TIC=15561000 Acnt:GUELPH Sys:350E HMR: 2405000
Text: SAMPLE #90 1600MV 50-10-320 7/6/84 Cal:350EMASS: 55.049



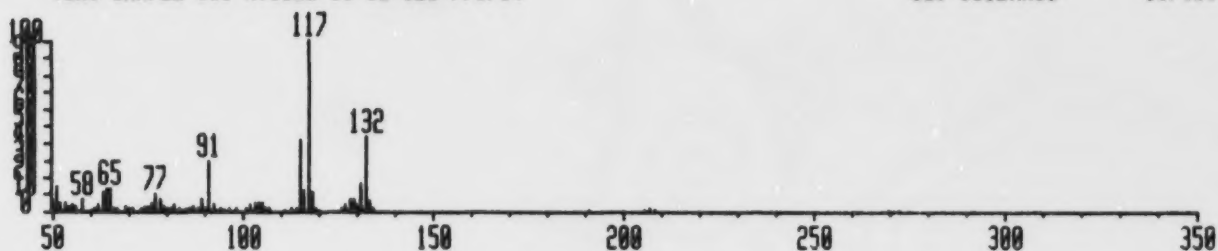
APPENDIX III B

Mass Spectrum of FHP
Products of Phenanthrene

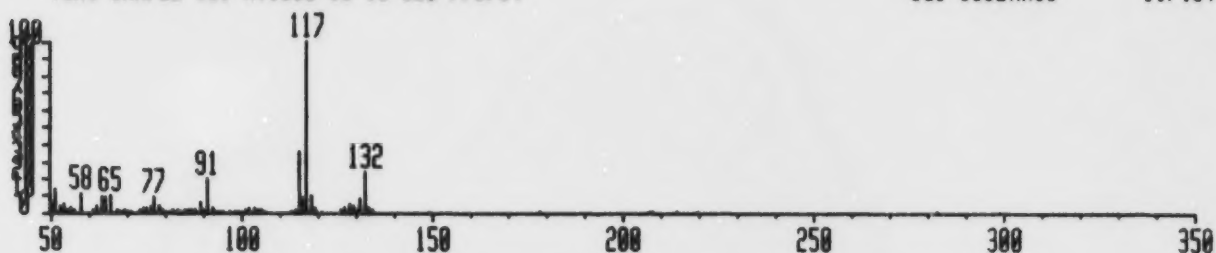
R91#271* x1 Bgd=1 6-JUL-84 12:02+0:05:35 12250 EI+
 BpM=0 I=76mv Hm=0 TIC=1595000 Acnt: GUELPH Sys: 350E HMR: 502000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 91.041



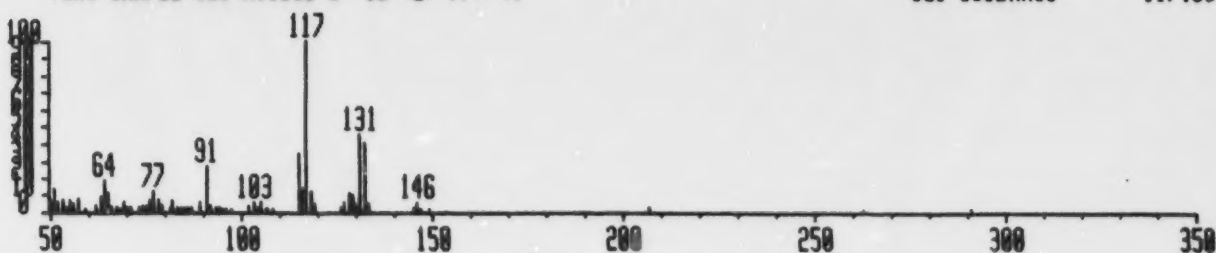
R91#291* x1 Bgd=1 6-JUL-84 12:02+0:05:59 12250 EI+
 BpM=0 I=87mv Hm=0 TIC=2550000 Acnt: GUELPH Sys: 350E HMR: 574000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 117.05



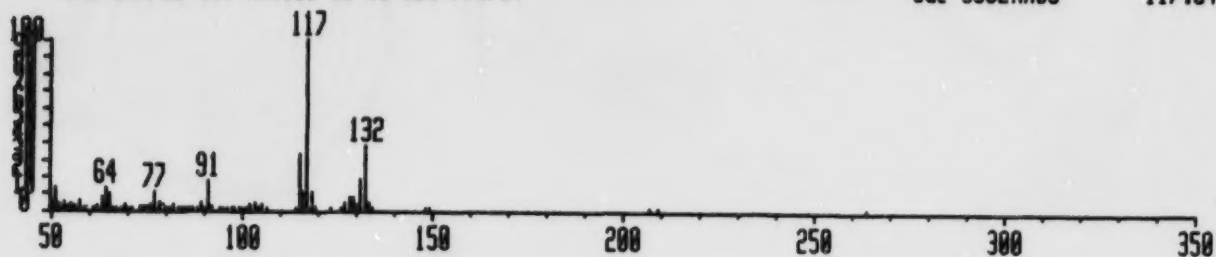
R91#296* x1 Bgd=1 6-JUL-84 12:02+0:06:05 12250 EI+
 BpM=0 I=179mv Hm=0 TIC=4004000 Acnt: GUELPH Sys: 350E HMR: 117700
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 117.04



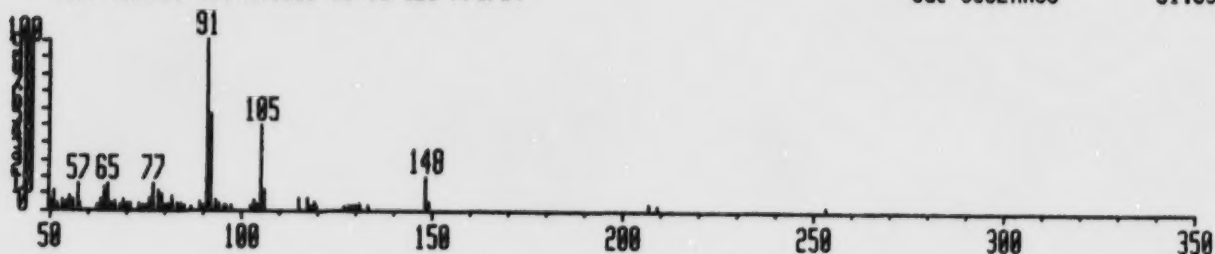
R91#339* x1 Bgd=1 6-JUL-84 12:02+0:06:57 12250 EI+
 BpM=0 I=41mv Hm=0 TIC=1413000 Acnt: GUELPH Sys: 350E HMR: 27000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 117.03



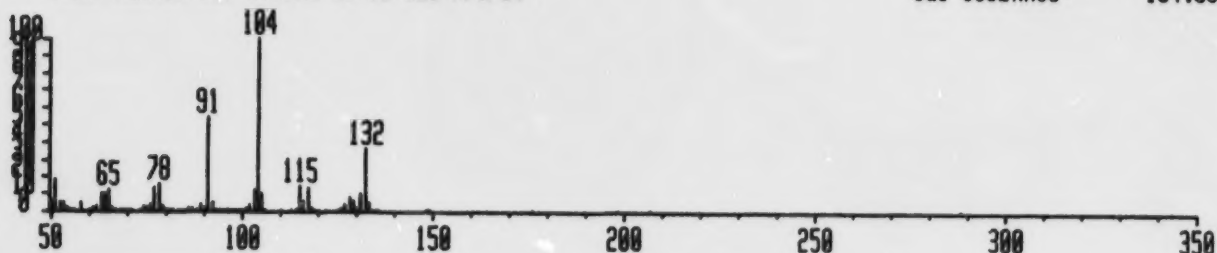
R91#348* x1 Bgd=1 6-JUL-84 12:02:07:00 12250 EI+
BpM=0 I=74mv Hm=0 TIC=2014000 Acnt:GUELPH Sys:350E HMR: 406006
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 117.04%



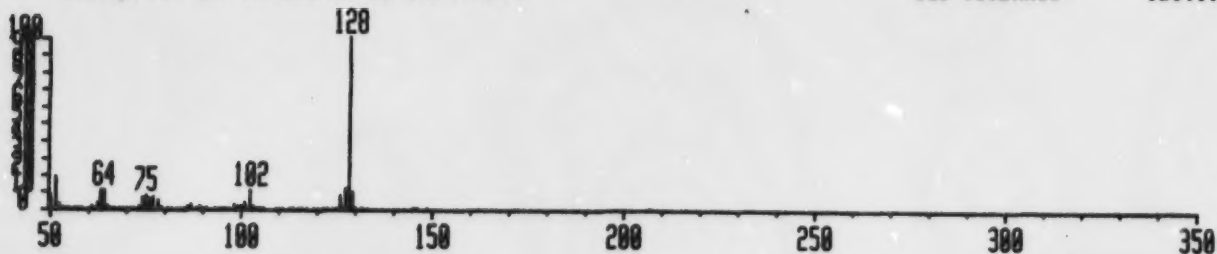
R91#354* x1 Bgd=1 6-JUL-84 12:02:07:15 12250 EI+
BpM=0 I=33mv Hm=0 TIC=1007000 Acnt:GUELPH Sys:350E HMR: 217001
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 91.03



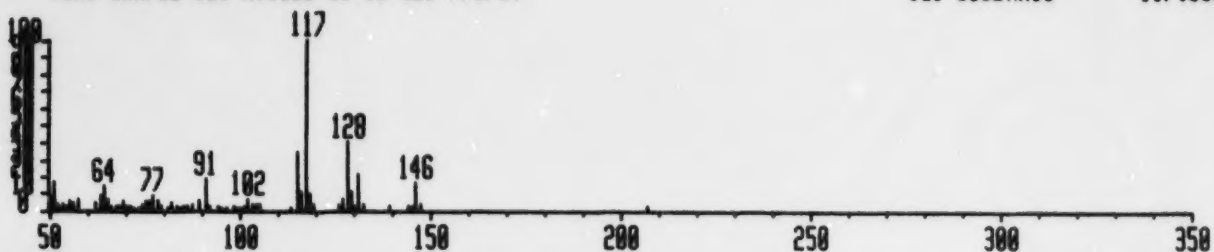
R91#358* x1 Bgd=356 6-JUL-84 12:02:07:20 12250 EI+
BpM=0 I=900mv Hm=0 TIC=23902000 Acnt:GUELPH Sys:350E HMR: 595100
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 104.09



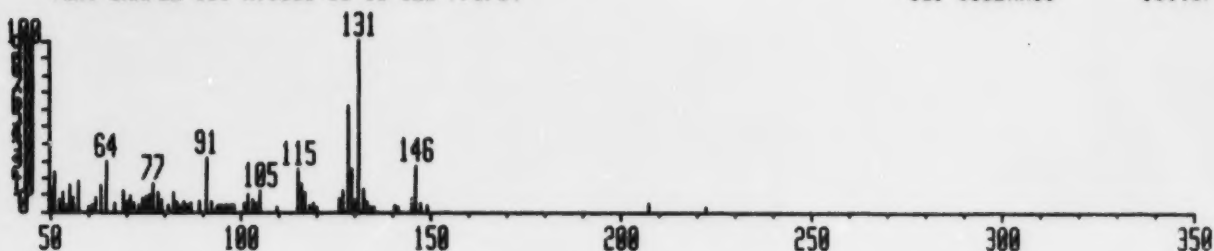
R91#376* x1 Bgd=371 6-JUL-84 12:02:07:42 12250 EI+
BpM=0 I=2.5v Hm=0 TIC=39592000 Acnt:GUELPH Sys:350E HMR: 1652500
Text: SMPLE 91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 120.11



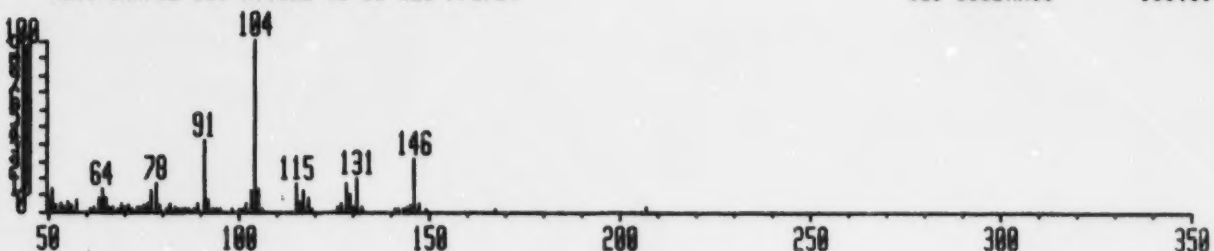
R91#383* x1 Bgd=371 6-JUL-84 12:02:0:07:50 12250 EI+
BpM=0 I=46mv Hm=0 TIC=1430000 Acnt:GUELPH Sys:350E HMR: 307000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 117.056



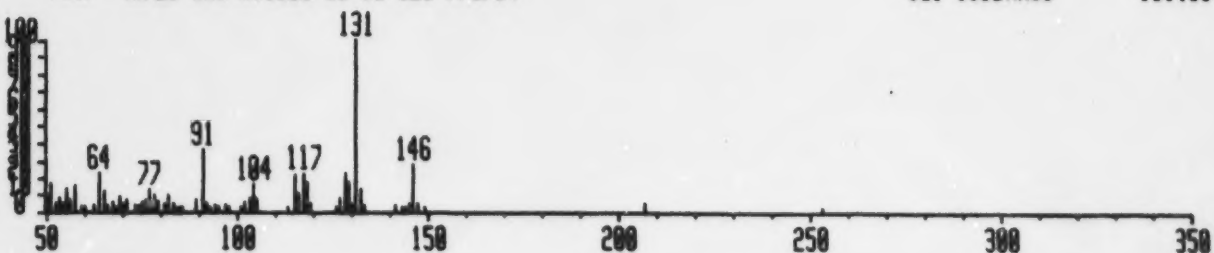
R91#387* x1 Bgd=371 6-JUL-84 12:02:0:07:55 12250 EI+
BpM=0 I=21mv Hm=0 TIC=1036000 Acnt:GUELPH Sys:350E HMR: 143001
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 131.071



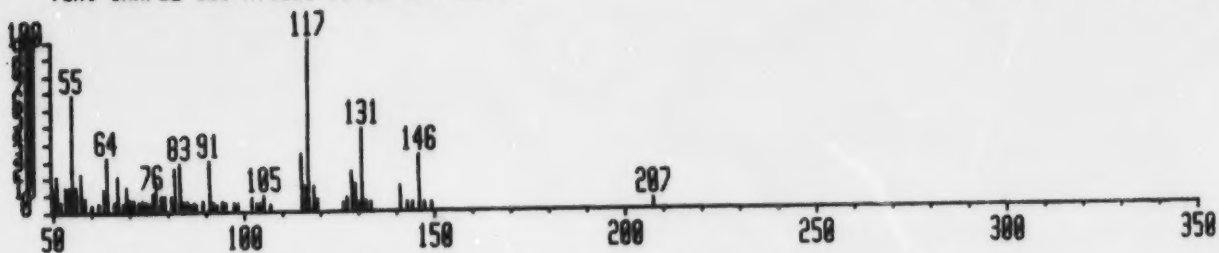
R91#481* x1 Bgd=371 6-JUL-84 12:02:0:08:12 12250 EI+
BpM=0 I=58mv Hm=0 TIC=1041000 Acnt:GUELPH Sys:350E HMR: 30400
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 103.99



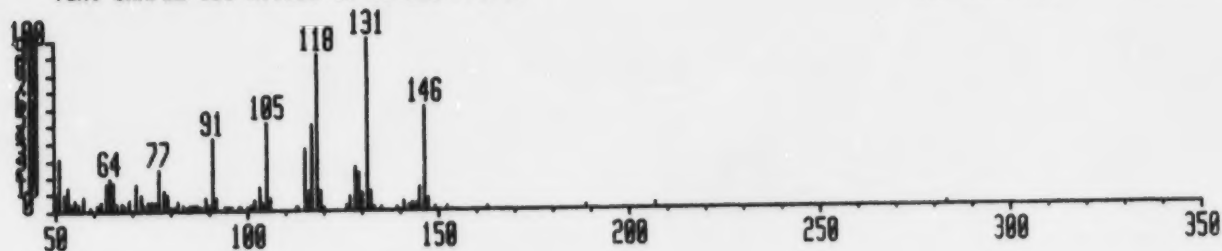
R91#488* x1 Bgd=371 6-JUL-84 12:02:0:08:20 12250 EI+
BpM=0 I=23mv Hm=0 TIC=949000 Acnt:GUELPH Sys:350E HMR: 15500
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 131.06



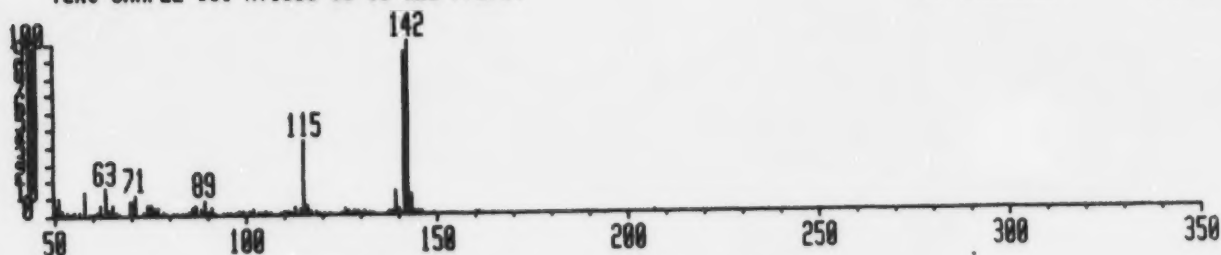
R91#416+ x1 Bgd=371 6-JUL-84 12:02:0:00:30 12250 EI+
 BpM=0 I=16mv Hm=0 TIC=913000 Acnt:GUELPH Sys:350E HMR: 106000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 117.030



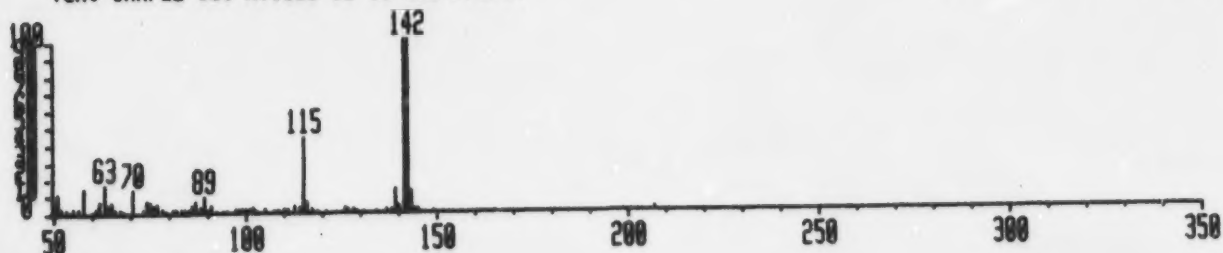
R91#440+ x1 Bgd=371 6-JUL-84 12:02:0:00:59 12250 EI+
 BpM=0 I=56mv Hm=0 TIC=3176000 Acnt:GUELPH Sys:350E HMR: 37000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 131.170



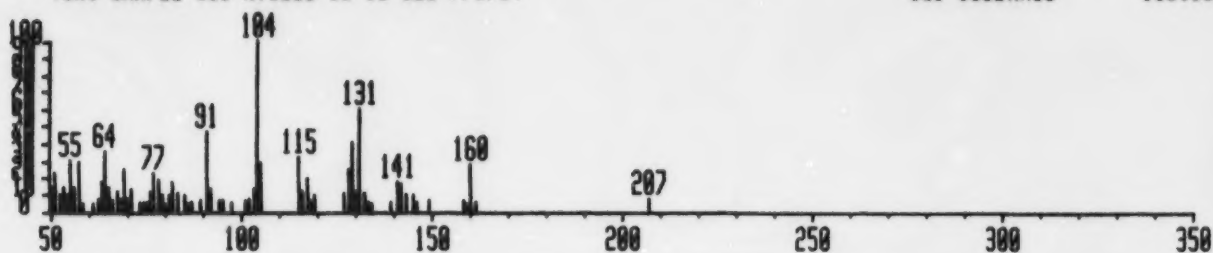
R91#462+ x1 Bgd=457 6-JUL-84 12:02:0:09:25 12250 EI+
 BpM=0 I=306mv Hm=0 TIC=10700000 Acnt:GUELPH Sys:350E HMR: 253300
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 142.180



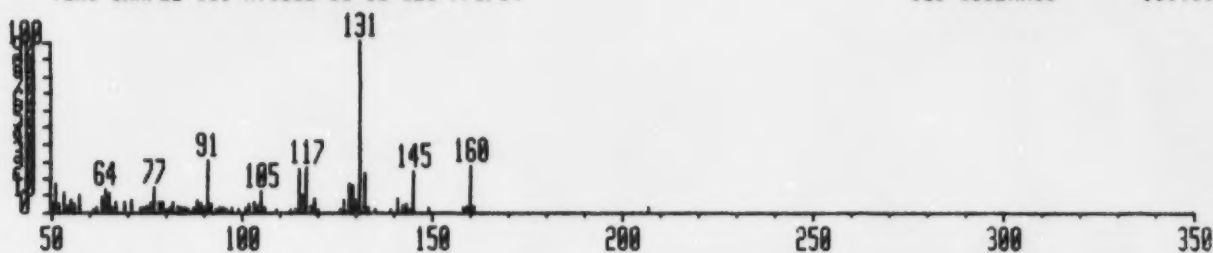
R91#475+ x1 Bgd=457 6-JUL-84 12:02:0:09:41 12250 EI+
 BpM=0 I=157mv Hm=0 TIC=4510000 Acnt:GUELPH Sys:350E HMR: 103400
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 142.160



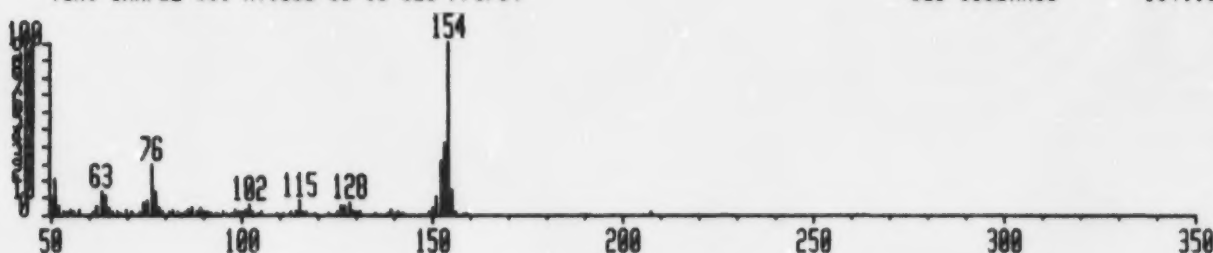
R91#489* x1 Bgd=457 6-JUL-84 12:02:0:09:50 12250 EI+
BpM=0 I=11mv Hm=0 TIC=009000 Acnt:GUELPH Sys:350E HMR: 70000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 103.991



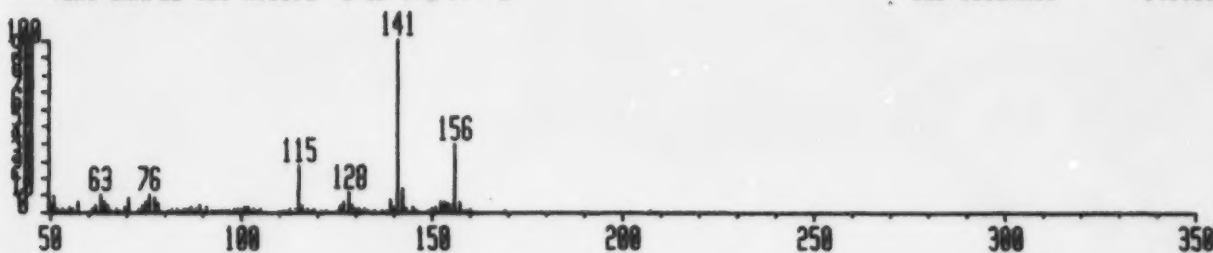
R91#510* x1 Bgd=457 6-JUL-84 12:02:0:10:23 12250 EI+
BpM=0 I=42mv Hm=0 TIC=1616000 Acnt:GUELPH Sys:350E HMR: 279000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 131.069



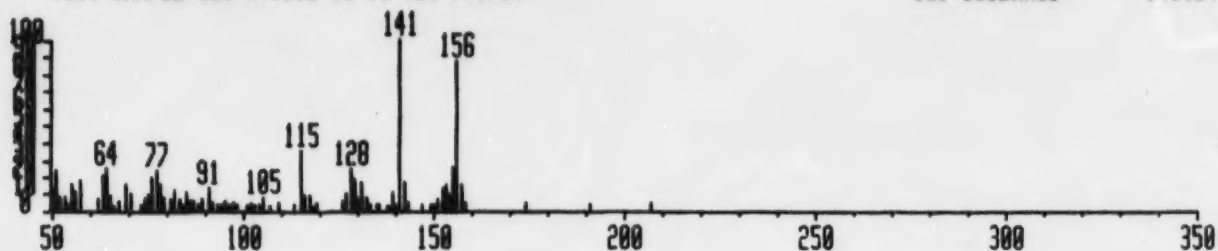
R91#525* x1 Bgd=457 6-JUL-84 12:02:0:10:42 12250 EI+
BpM=0 I=145mv Hm=0 TIC=3900000 Acnt:GUELPH Sys:350E HMR: 95300
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 154.16



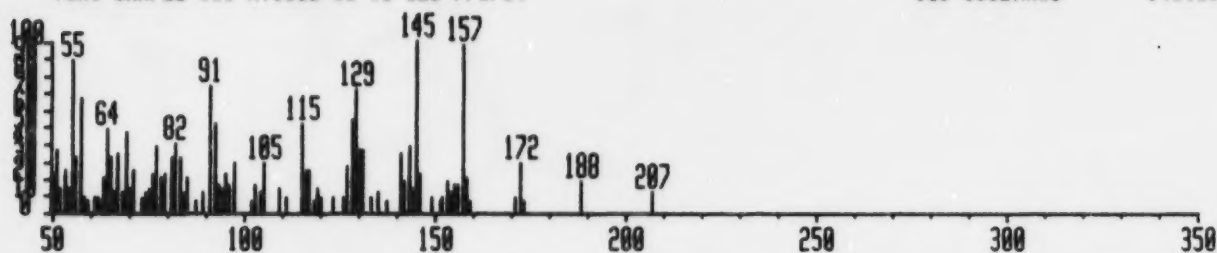
R91#535* x1 Bgd=457 6-JUL-84 12:02:0:10:54 12250 EI+
BpM=0 I=217mv Hm=0 TIC=5156000 Acnt:GUELPH Sys:350E HMR: 142400
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 141.05



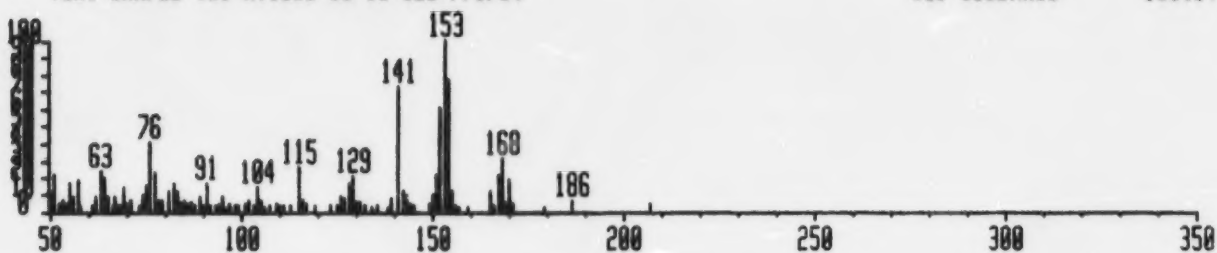
R910554* x1 Bgd=457 6-JUL-84 12:02:0:11:17 12250 EI+
 BpM=0 I=22mv Hm=0 TIC=1293000 Acnt: GUELPH Sys: 350E HMR: 145000
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal: 350EMASS: 141.048



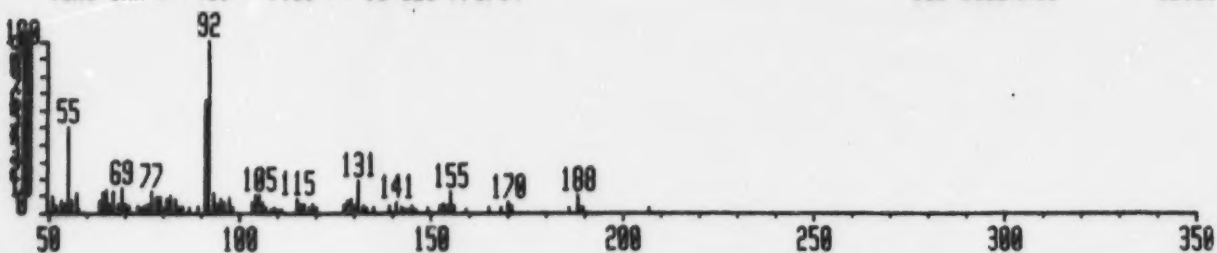
R910507* x1 Bgd=457 6-JUL-84 12:02:0:11:56 12250 EI+
 BpM=0 I=6.9mv Hm=0 TIC=935000 Acnt: GUELPH Sys: 350E HMR: 45000
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal: 350EMASS: 145.081



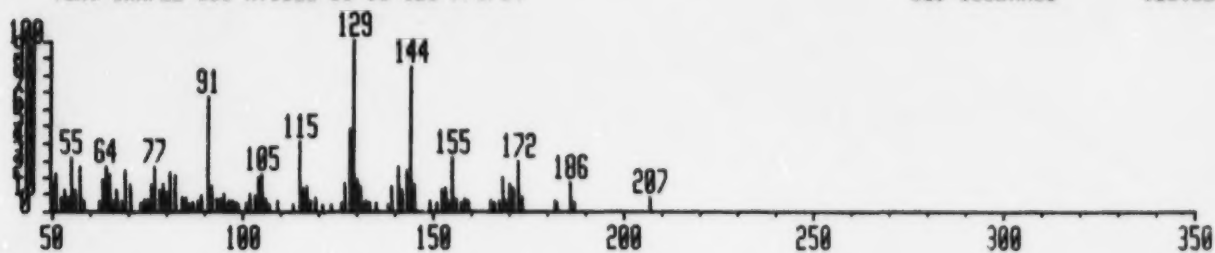
R910599* x1 Bgd=457 6-JUL-84 12:02:0:12:11 12250 EI+
 BpM=0 I=22mv Hm=0 TIC=1632000 Acnt: GUELPH Sys: 350E HMR: 14900
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal: 350EMASS: 153.04



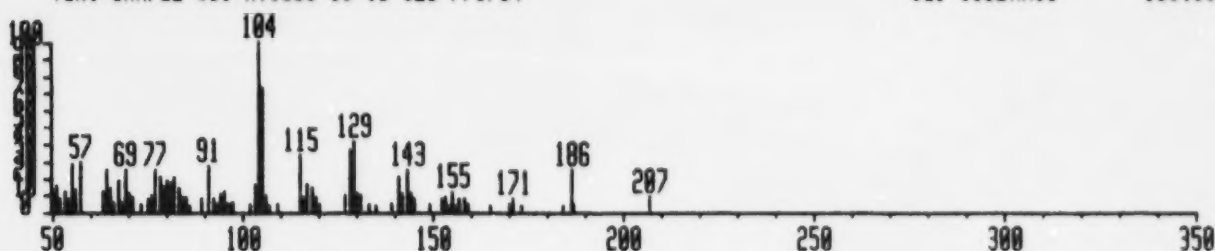
R910620* x1 Bgd=457 6-JUL-84 12:02:0:12:36 12250 EI+
 BpM=0 I=32mv Hm=0 TIC=1340000 Acnt: GUELPH Sys: 350E HMR: 21500
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal: 350EMASS: 92.03



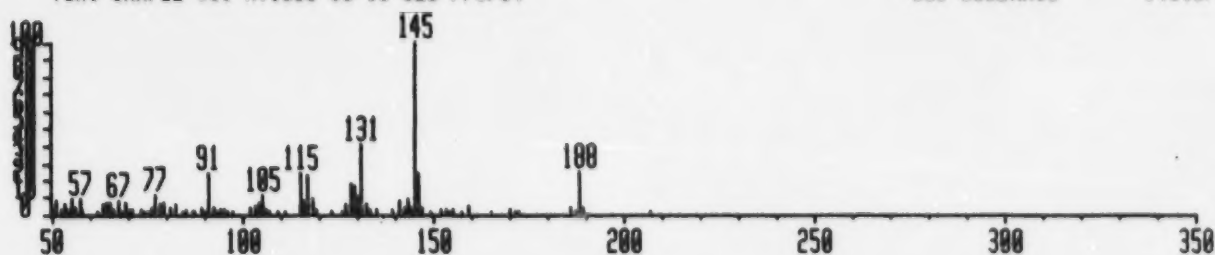
R910624+ x1 Bgd=457 6-JUL-84 12:02:0:12:41 12250 EI+
BpM=0 I=14mv Hm=0 TIC=1200000 Acnt: GUELPH Sys: 350E HMR: 95000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 129.022



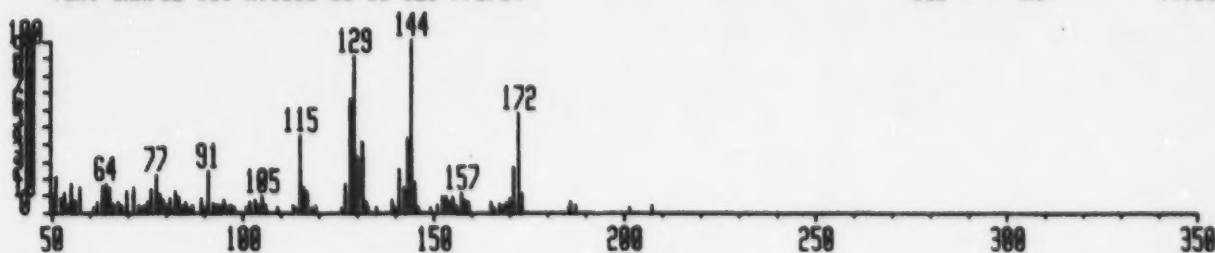
R910630+ x1 Bgd=457 6-JUL-84 12:02:0:12:50 12250 EI+
BpM=0 I=13mv Hm=0 TIC=953000 Acnt: GUELPH Sys: 350E HMR: 87000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 103.992



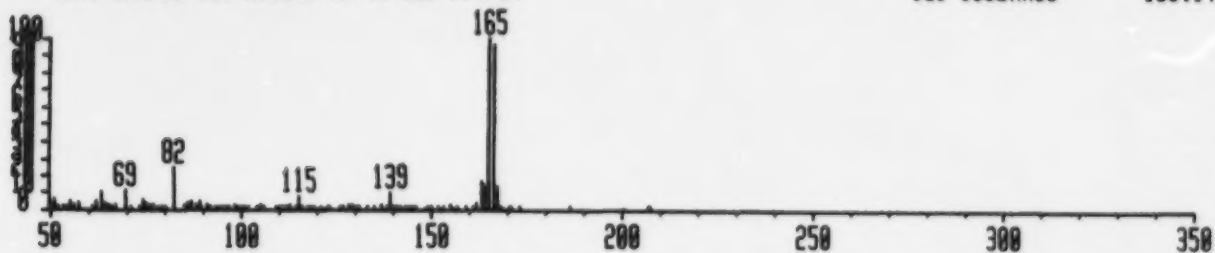
R910645+ x1 Bgd=457 6-JUL-84 12:02:0:13:06 12250 EI+
BpM=0 I=50mv Hm=0 TIC=1063000 Acnt: GUELPH Sys: 350E HMR: 33100
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 145.07



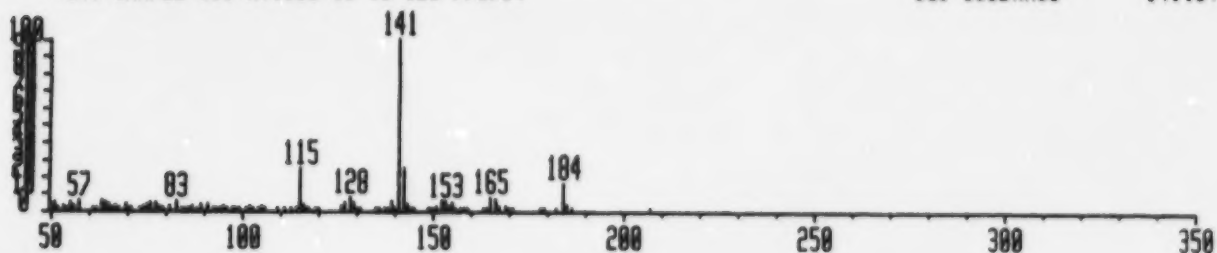
R910655+ x1 Bgd=457 6-JUL-84 12:02:0:13:19 12250 EI+
BpM=0 I=20mv Hm=0 TIC=2032000 Acnt: GUELPH Sys: 350E HMR: 10500
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 14.06



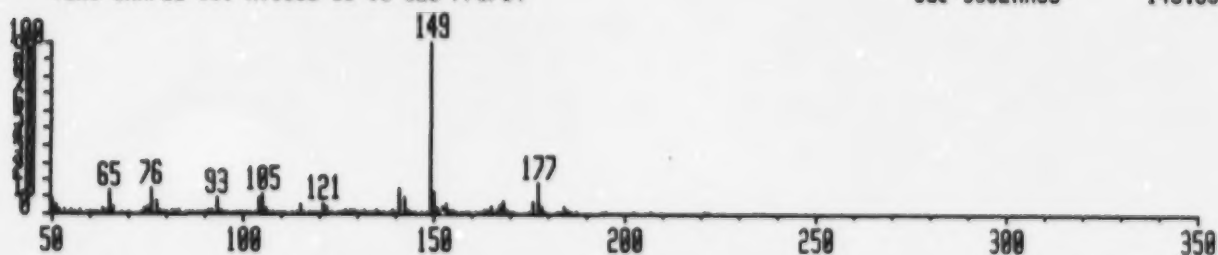
R910664* x1 Bgd=457 6-JUL-84 12:02:0:13:29 12250 EI+
 BpM=0 I=115mv Hm=0 TIC=3237000 Acnt:GUELPH Sys:350E HMR: 755000
 Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 165.142



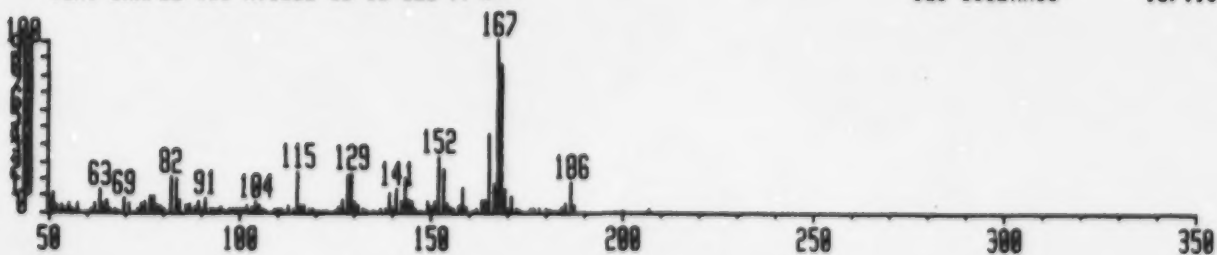
R910667* x1 Bgd=457 6-JUL-84 12:02:0:13:33 12250 EI+
 BpM=0 I=77mv Hm=0 TIC=1859000 Acnt:GUELPH Sys:350E HMR: 510000
 Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 141.040



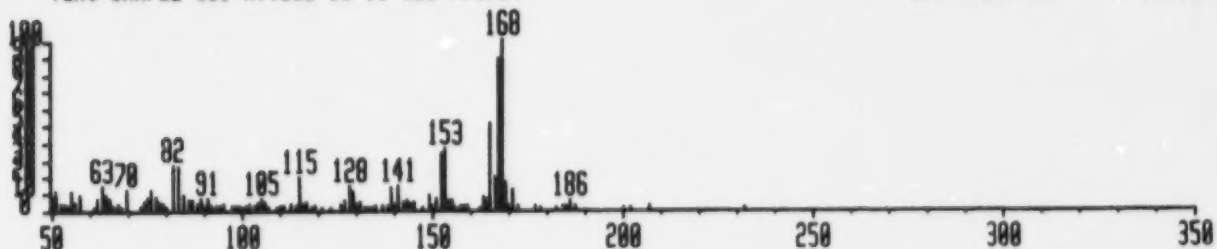
R910671* x1 Bgd=660 6-JUL-84 12:02:0:13:38 12250 EI+
 BpM=0 I=762mv Hm=0 TIC=16292000 Acnt:GUELPH Sys:350E HMR: 499000
 Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 149.09



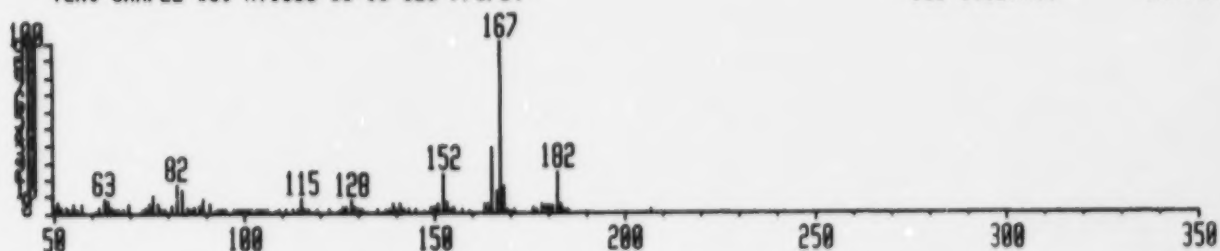
R910676* x1 Bgd=660 6-JUL-84 12:02:0:13:44 12250 EI+
 BpM=0 I=160mv Hm=0 TIC=8192000 Acnt:GUELPH Sys:350E HMR: 105400
 Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 167.15



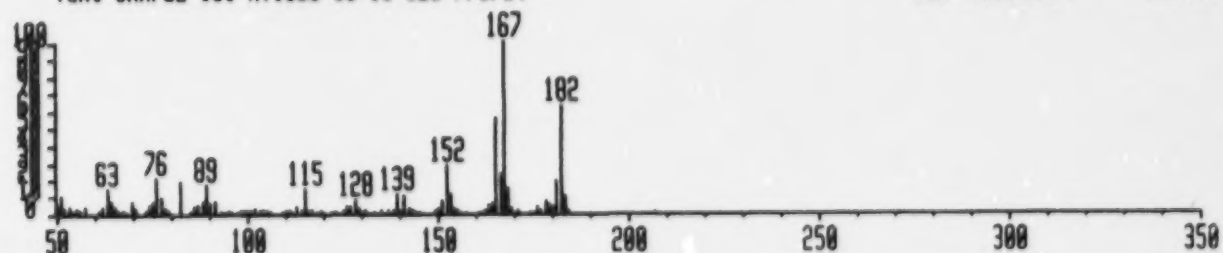
R910681* x1 Bgd=668 6-JUL-84 12:02:0:13:50 12250 EI+
BpM=0 I=47mv Hm=0 TIC=2604000 Acnt:GUELPH Sys:350E HMR: 311000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 168.163



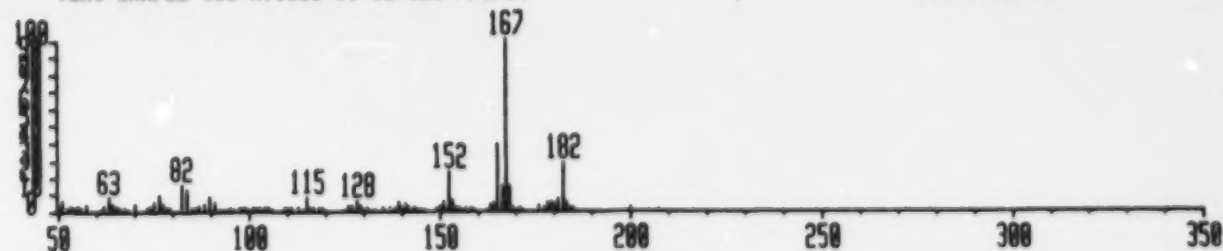
R910694* x1 Bgd=668 6-JUL-84 12:02:0:14:06 12250 EI+
BpM=0 I=88mv Hm=0 TIC=2581000 Acnt:GUELPH Sys:350E HMR: 577000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 167.160



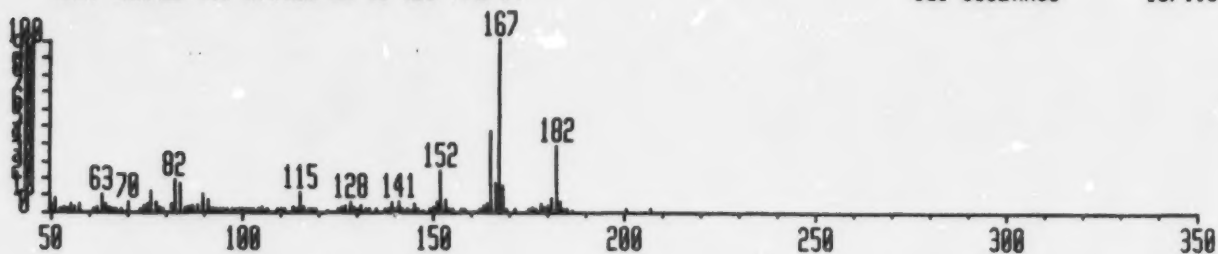
R910700* x1 Bgd=668 6-JUL-84 12:02:0:14:13 12250 EI+
BpM=0 I=165mv Hm=0 TIC=6650000 Acnt:GUELPH Sys:350E HMR: 100500
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 167.14



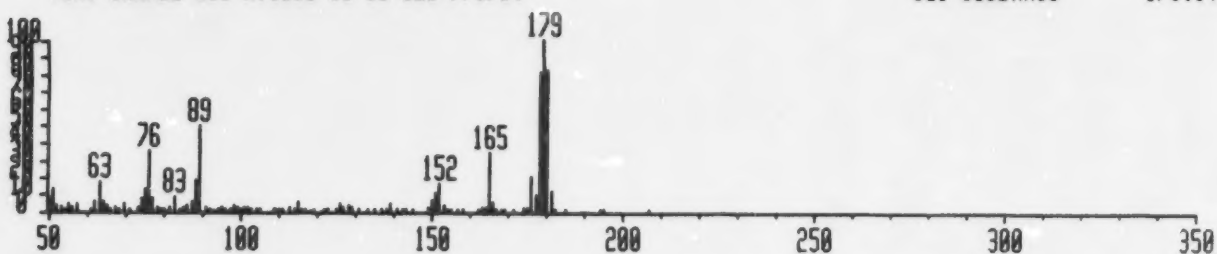
R910705* x1 Bgd=668 6-JUL-84 12:02:0:14:19 12250 EI+
BpM=0 I=154mv Hm=0 TIC=4329000 Acnt:GUELPH Sys:350E HMR: 101000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 167.15



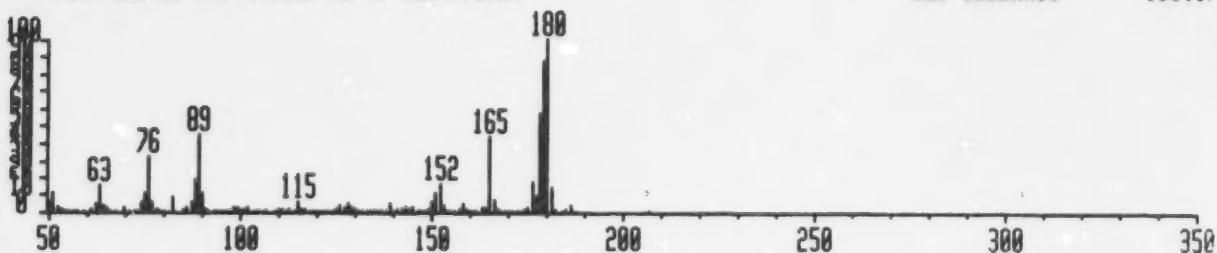
R91#711* x1 Bgd=668 6-JUL-84 12:02:0:14:26 12250 EI+
BpM=0 I=106mv Hm=0 TIC=3640000 Acnt: GUELPH Sys: 350E HMR: 700000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 167.163



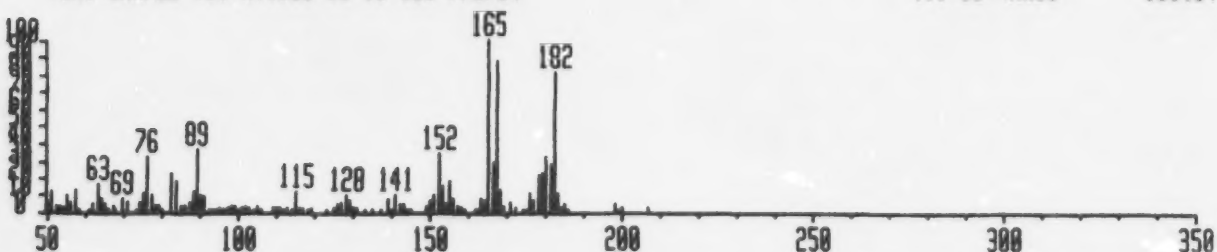
R91#724* x1 Bgd=668 6-JUL-84 12:02:0:14:42 12250 EI+
BpM=0 I=95mv Hm=0 TIC=4380000 Acnt: GUELPH Sys: 350E HMR: 625000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 179.14'



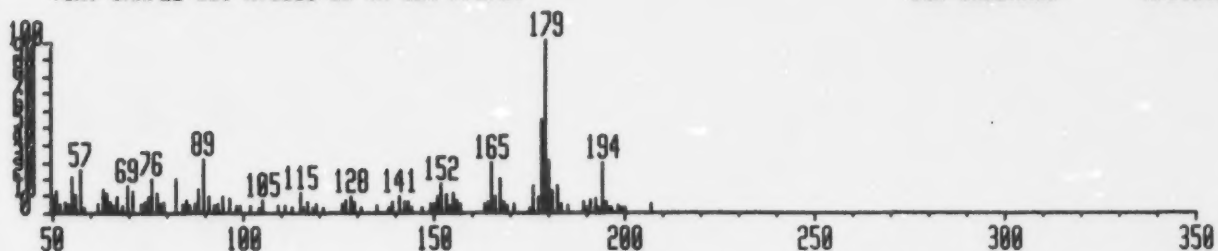
R91#733* x1 Bgd=729 6-JUL-84 12:02:0:14:53 12250 EI+
BpM=0 I=2.0v Hm=0 TIC=82355000 Acnt: GUELPH Sys: 350E HMR: 1299900
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 180.17



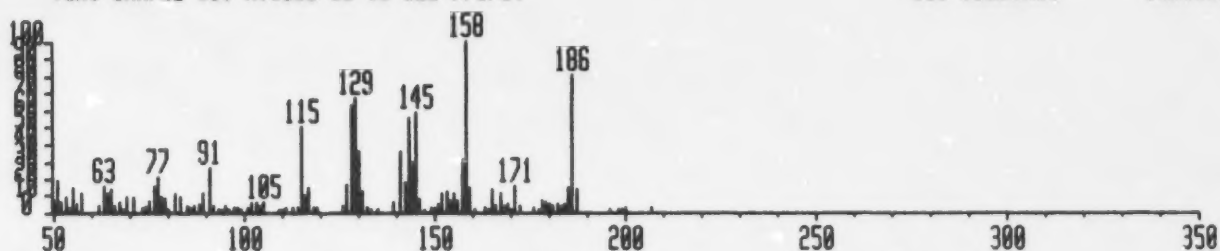
R91#741* x1 Bgd=729 6-JUL-84 12:02:0:15:02 12250 EI+
BpM=0 I=56mv Hm=0 TIC=3712000 Acnt: GUELPH Sys: 350F HMR: 37200
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 165.04



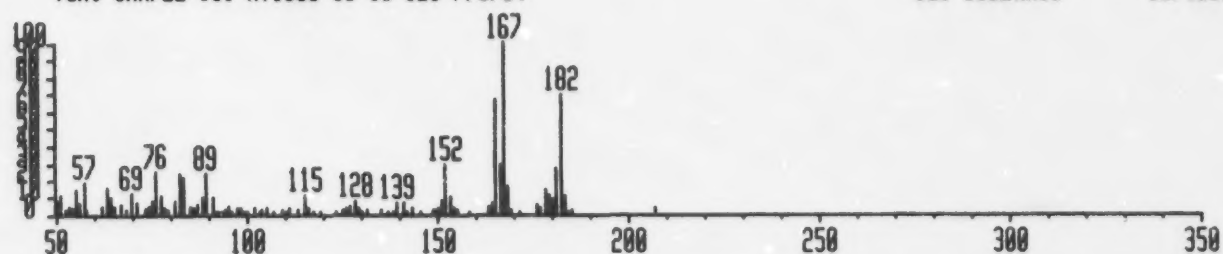
R91#745* x1 Bgd=729 6-JUL-84 12:02:0:15:07 12250 EI+
BpM=0 I=24uv Hm=0 TIC=1442000 Acnt:GUELPH Sys:350E HMR: 160000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 179.040



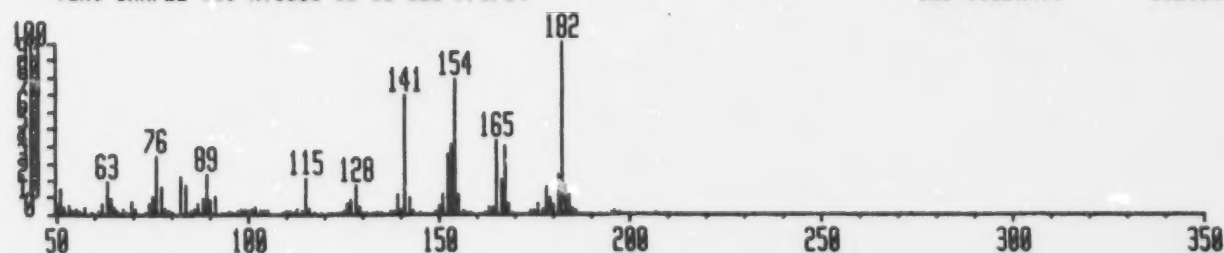
R91#750* x1 Bgd=729 6-JUL-84 12:02:0:15:13 12250 EI+
BpM=0 I=56uv Hm=0 TIC=4393000 Acnt:GUELPH Sys:350E HMR: 369000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 150.105



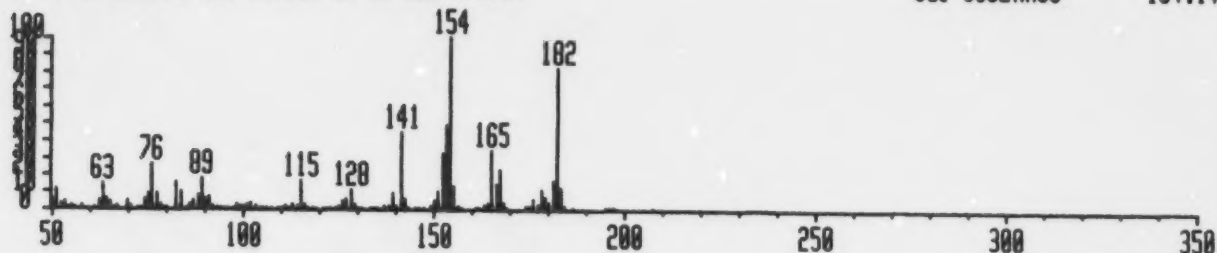
R91#750* x1 Bgd=729 6-JUL-84 12:02:0:15:23 12250 EI+
BpM=0 I=39uv Hm=0 TIC=2131000 Acnt:GUELPH Sys:350E HMR: 250000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 167.050



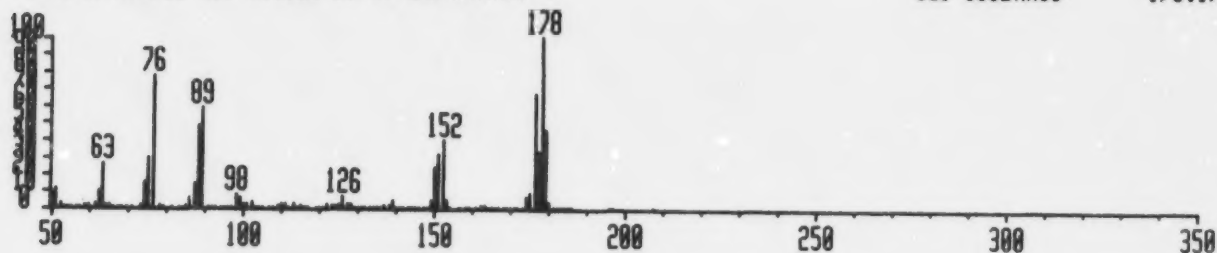
R91#760* x1 Bgd=764 6-JUL-84 12:02:0:15:35 12250 EI+
BpM=0 I=206uv Hm=0 TIC=16710000 Acnt:GUELPH Sys:350E HMR: 1077000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 102.190



R91#772* x1 Bgd=769 6-JUL-84 12:02:0:15:40 12250 EI+
BpM=0 I=972mv Hm=0 TIC=45679000 Acnt:GUELPH Sys:350E HMR: 6370000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 154.147



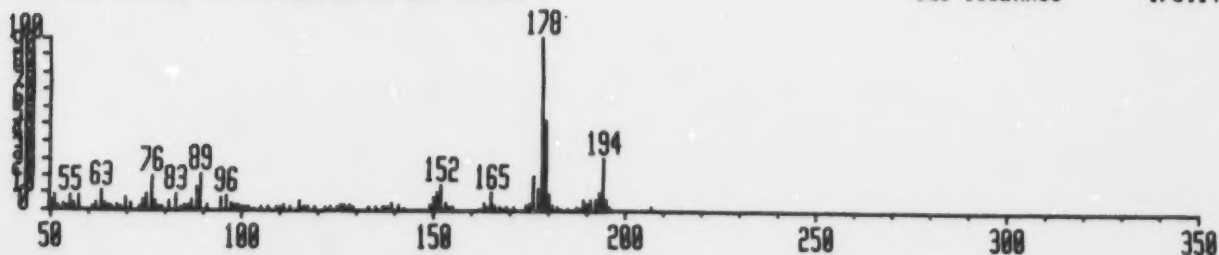
R91#789* x1 Bgd=780 6-JUL-84 12:02:0:16:00 12250 EI+
BpM=0 I=10v Hm=0 TIC=479716000 Acnt:GUELPH Sys:350E HMR: 65534000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 170.174



R91#792* x1 Bgd=780 6-JUL-84 12:02:0:16:04 12250 EI+
BpM=0 I=232mv Hm=0 TIC=5332000 Acnt:GUELPH Sys:350E HMR: 1526000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 170.145



R91#796* x1 Bgd=780 6-JUL-84 12:02:0:16:09 12250 EI+
BpM=0 I=87mv Hm=0 TIC=3164000 Acnt:GUELPH Sys:350E HMR: 575000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 170.146



R91#814* x1 Bgd=700 6-JUL-84 12:02:0:16:31 12250 EI+

BpM=0 I=25mv Hm=0 TIC=1347000

Acnt:GUELPH

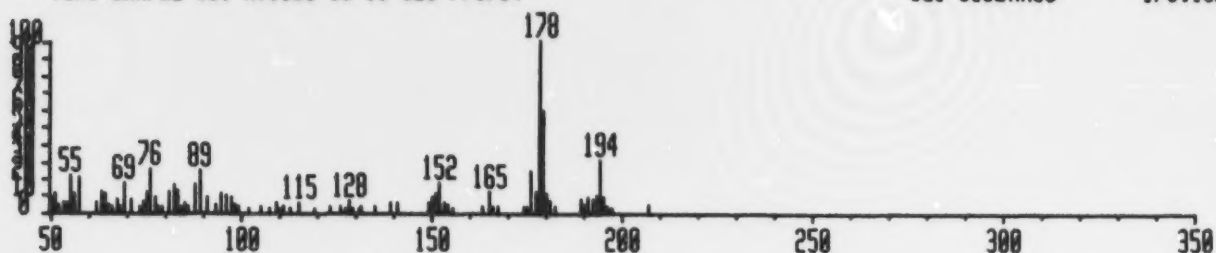
Sys:350E HMR:

160000

Text: SAMPLE #91 MV1600 50-10-320 7/6/84

Cal:350EMASS:

170.137



R91#834* x1 Bgd=700 6-JUL-84 12:02:0:16:55 12250 EI+

BpM=0 I=22mv Hm=0 TIC=2039000

Acnt:GUELPH

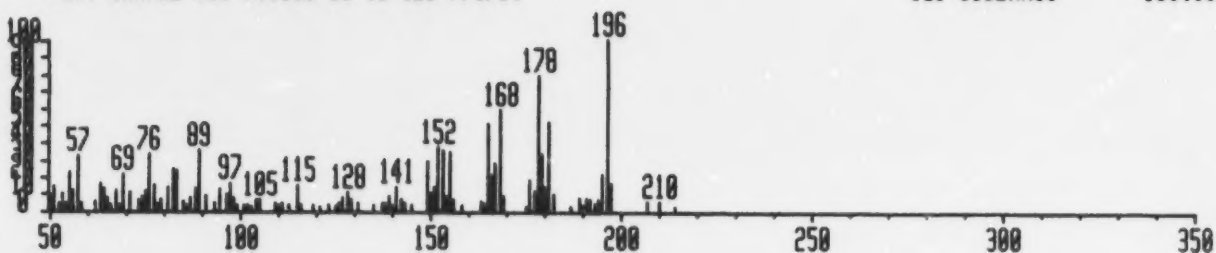
Sys:350E HMR:

148000

Text: SAMPLE #91 MV1600 50-10-320 7/6/84

Cal:350EMASS:

196.190



R91#838* x1 Bgd=700 6-JUL-84 12:02:0:17:00 12250 EI+

BpM=0 I=13mv Hm=0 TIC=1317000

Acnt:GUELPH

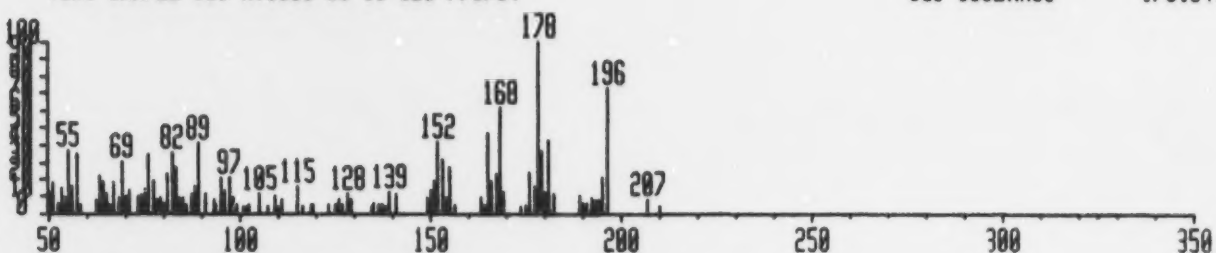
Sys:350E HMR:

87000

Text: SAMPLE #91 MV1600 50-10-320 7/6/84

Cal:350EMASS:

170.041



R91#847* x1 Bgd=700 6-JUL-84 12:02:0:17:10 12250 EI+

BpM=0 I=18mv Hm=0 TIC=1307000

Acnt:GUELPH

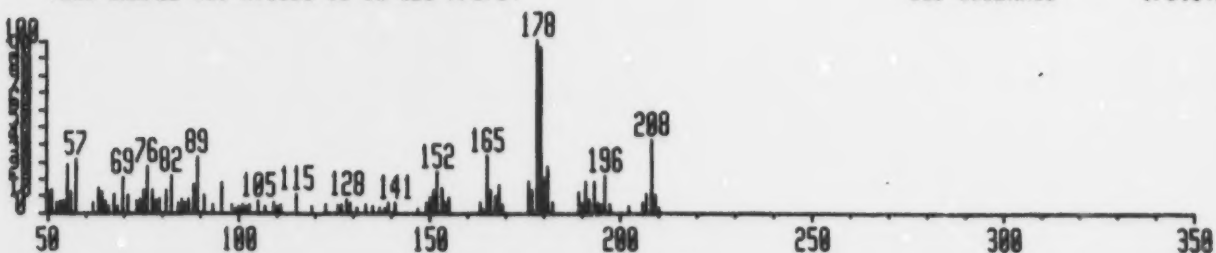
Sys:350E HMR:

122000

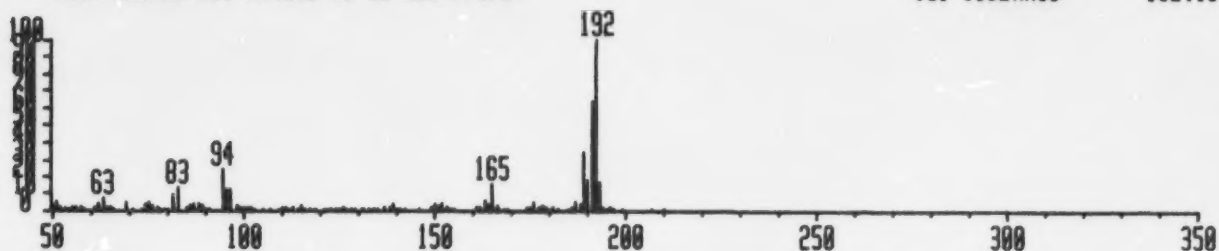
Text: SAMPLE #91 MV1600 50-10-320 7/6/84

Cal:350EMASS:

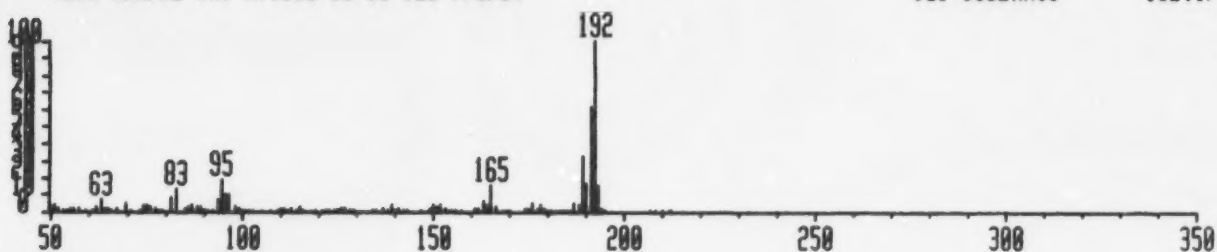
170.041



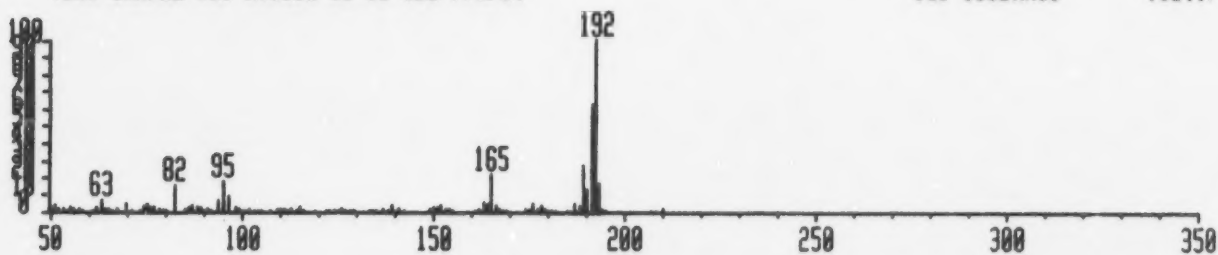
R91#851* x1 Bgd=849 6-JUL-84 12:02:0:17:15 12250 EI+
BpM=0 I=452mv Hm=0 TIC=12942000 Acnt:GUELPH Sys:350E HMR: 2962000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 192.154



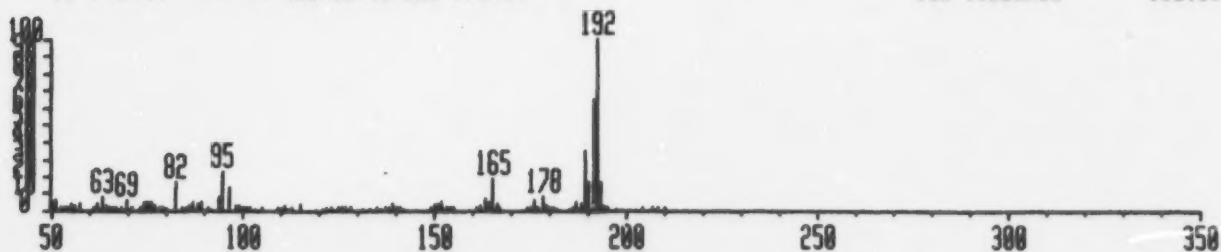
R91#854* x1 Bgd=849 6-JUL-84 12:02:0:17:19 12250 EI+
BpM=0 I=398mv Hm=0 TIC=10081000 Acnt:GUELPH Sys:350E HMR: 2610000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 192.173



R91#865* x1 Bgd=849 6-JUL-84 12:02:0:17:32 12250 EI+
BpM=0 I=303mv Hm=0 TIC=8150000 Acnt:GUELPH Sys:350E HMR: 1990000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 192.173



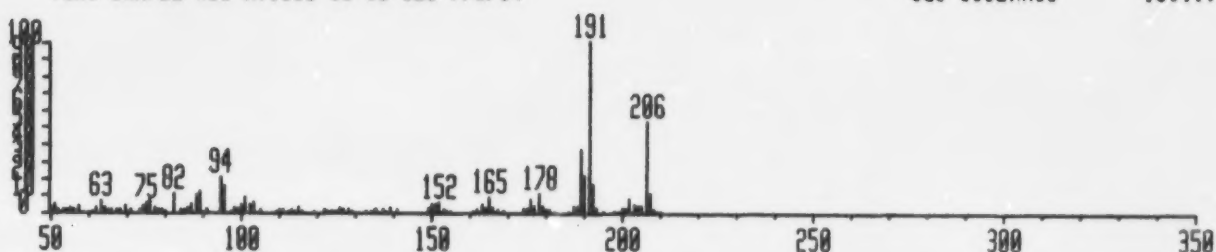
R91#868* x1 Bgd=849 6-JUL-84 12:02:0:17:36 12250 EI+
BpM=0 I=122mv Hm=0 TIC=3913000 Acnt:GUELPH Sys:350E HMR: 803000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 192.164



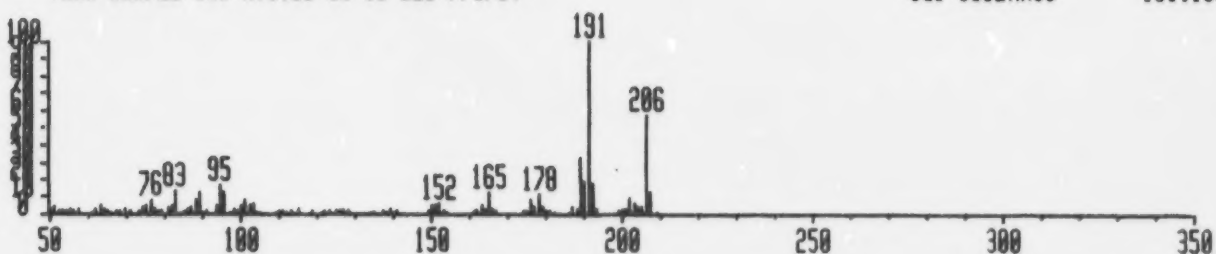
R91#884* x1 Bgd=849 6-JUL-84 12:02:0:17:55 12250 EI+
 BpM=0 I=126mv Hm=0 TIC=2290000 Acnt:GUELPH Sys:350E HMR: 826000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 149.000



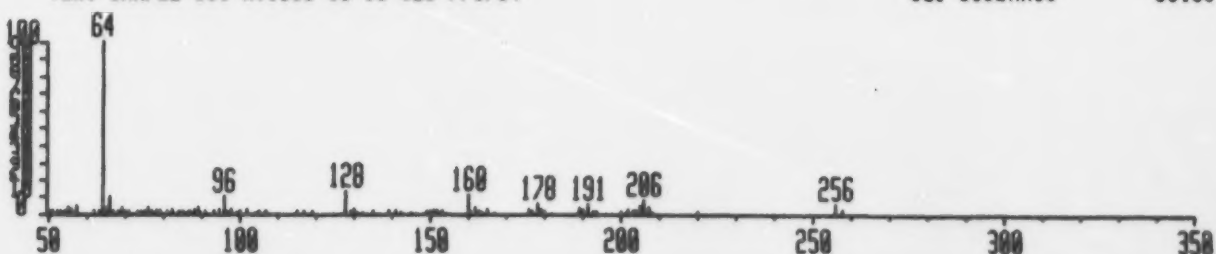
R91#902* x1 Bgd=849 6-JUL-84 12:02:0:18:17 12250 EI+
 BpM=0 I=152mv Hm=0 TIC=5106000 Acnt:GUELPH Sys:350E HMR: 996000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 191.151



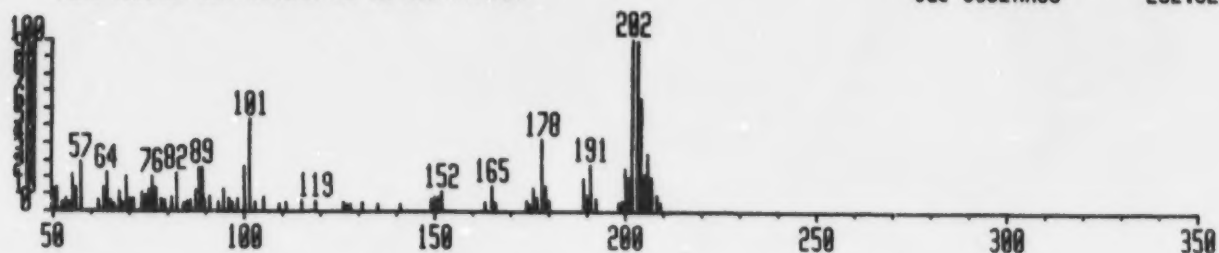
R91#911* x1 Bgd=849 6-JUL-84 12:02:0:18:20 12250 EI+
 BpM=0 I=150mv Hm=0 TIC=5220000 Acnt:GUELPH Sys:350E HMR: 1037000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 191.150



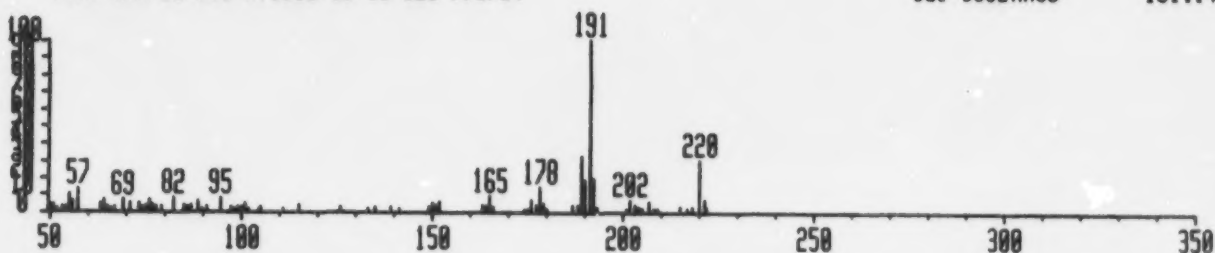
R91#930* x1 Bgd=849 6-JUL-84 12:02:0:18:51 12250 EI+
 BpM=0 I=115mv Hm=0 TIC=2029000 Acnt:GUELPH Sys:350E HMR: 754000
 Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 63.930



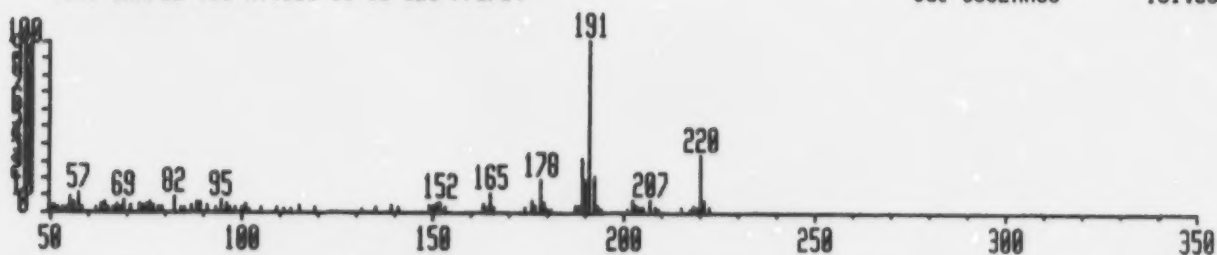
R91#937* x1 Bgd=049 6-JUL-84 12:02:0:18:59 12250 EI+
BpM=0 I=15mv Hm=0 TIC=1119000 Acnt:GUELPH Sys:350E HMR: 98000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 202.020



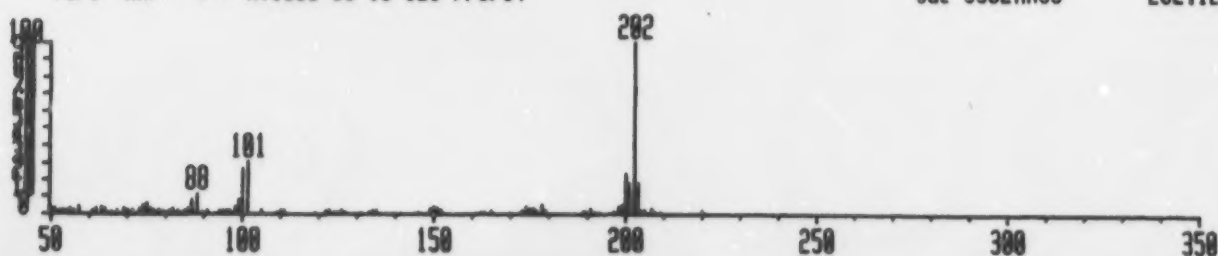
R91#951* x1 Bgd=049 6-JUL-84 12:02:0:19:16 12250 EI+
BpM=0 I=43mv Hm=0 TIC=1290000 Acnt:GUELPH Sys:350E HMR: 284000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 191.140



R91#963* x1 Bgd=049 6-JUL-84 12:02:0:19:31 12250 EI+
BpM=0 I=30mv Hm=0 TIC=1219000 Acnt:GUELPH Sys:350E HMR: 249000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 191.060

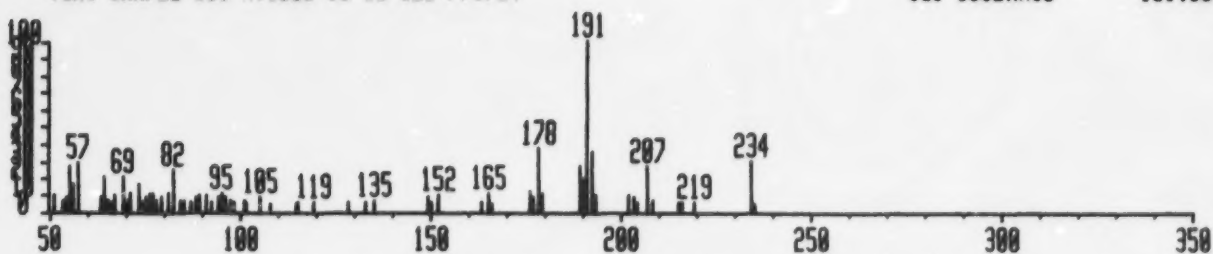


R91#969* x1 Bgd=049 6-JUL-84 12:02:0:19:30 12250 EI+
BpM=0 I=120mv Hm=0 TIC=2767000 Acnt:GUELPH Sys:350E HMR: 789000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 202.120

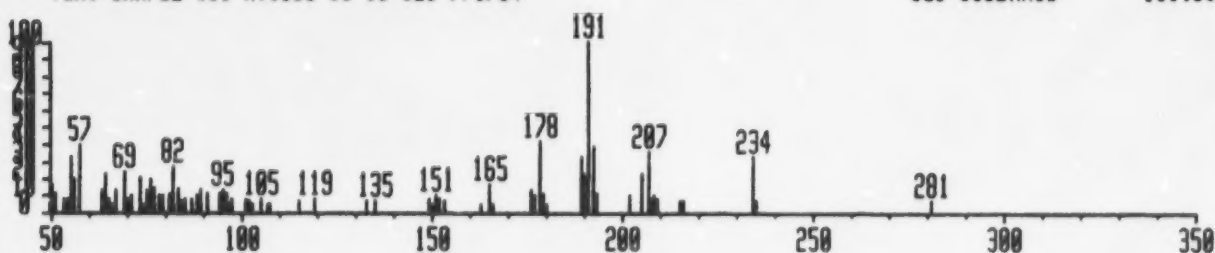


170

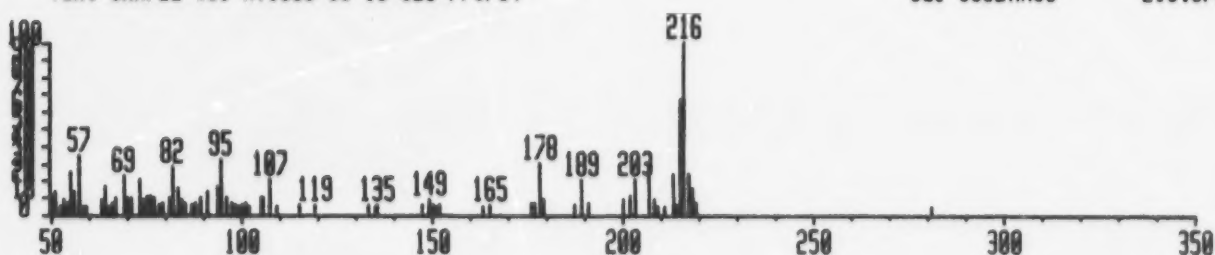
R91#1006* x1 Bgd=849 6-JUL-84 12:02:0:20:22 12250 EI+
BpM=0 I=11mv Hm=0 TIC=636000 Acnt:GUELPH Sys:350E HMR: 75000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 191.005



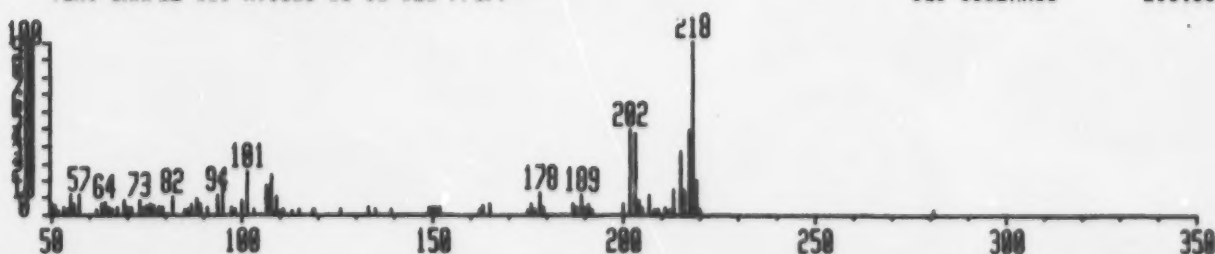
R91#1020* x1 Bgd=849 6-JUL-84 12:02:0:20:39 12250 EI+
BpM=0 I=9.8mv Hm=0 TIC=658000 Acnt:GUELPH Sys:350E HMR: 64000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 191.000



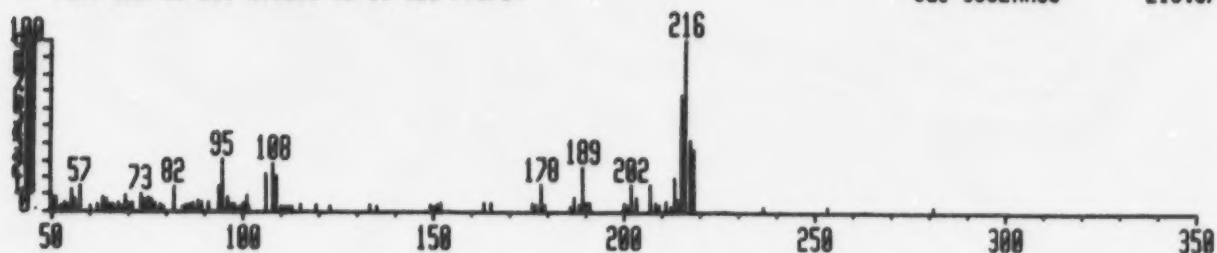
R91#1029* x1 Bgd=849 6-JUL-84 12:02:0:20:50 12250 EI+
BpM=0 I=11mv Hm=0 TIC=729000 Acnt:GUELPH Sys:350E HMR: 74000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 216.076



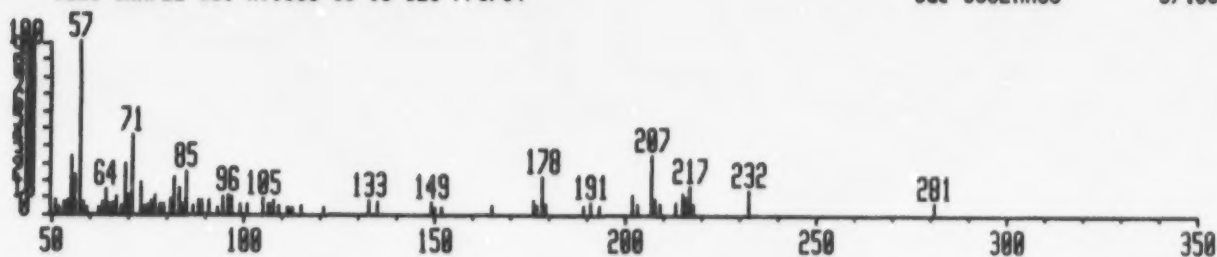
R91#1033* x1 Bgd=849 6-JUL-84 12:02:0:20:55 12250 EI+
BpM=0 I=34mv Hm=0 TIC=1653000 Acnt:GUELPH Sys:350E HMR: 227000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal: 350EMASS: 210.097



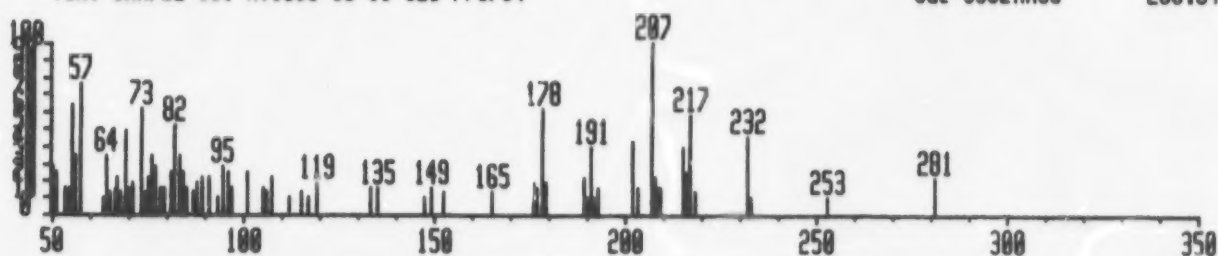
R91#1040+ x1 Bgd=849 6-JUL-84 12:02:0:21:04 12250 EI+
 BpM=0 I=26mv Hm=0 TIC=1343000 Acnt:GUELPH Sys:350E HMR: 172000
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal:350EMASS: 216.075



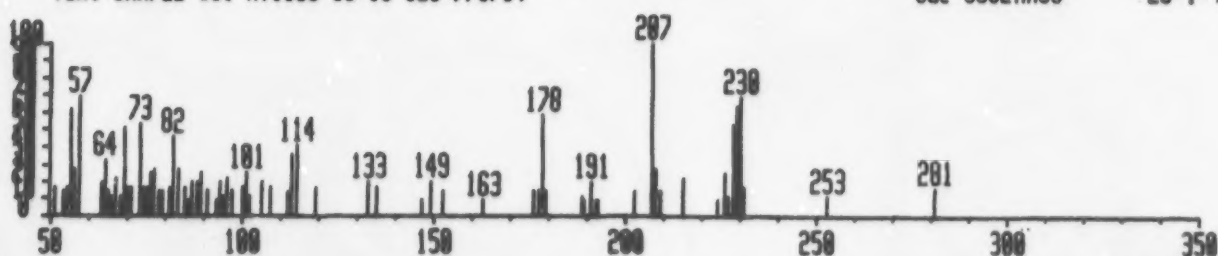
R91#1040+ x1 Bgd=849 6-JUL-84 12:02:0:21:13 12250 EI+
 BpM=0 I=13mv Hm=0 TIC=733000 Acnt:GUELPH Sys:350E HMR: 91000
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal:350EMASS: 57.065



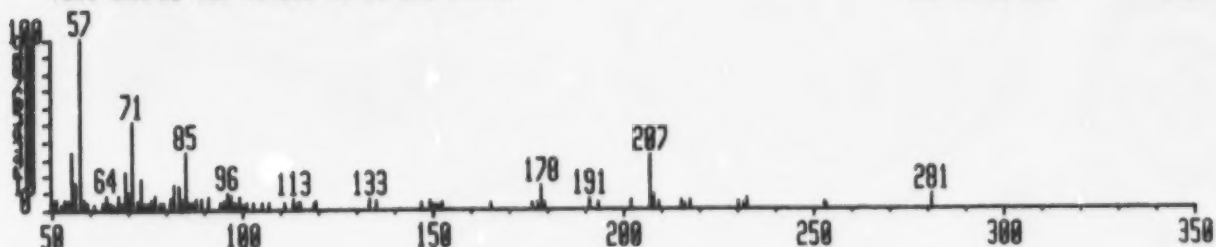
R91#1057+ x1 Bgd=849 6-JUL-84 12:02:0:21:24 12250 EI+
 BpM=0 I=5.0mv Hm=0 TIC=579000 Acnt:GUELPH Sys:350E HMR: 33000
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal:350EMASS: 206.944



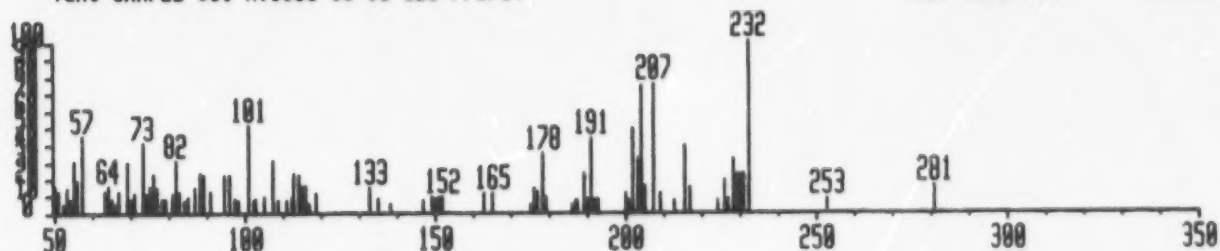
R91#1076+ x1 Bgd=849 6-JUL-84 12:02:0:21:47 12250 EI+
 BpM=0 I=5.0mv Hm=0 TIC=636000 Acnt:GUELPH Sys:350E HMR: 30000
 Text: SAMPLE #91 NV1600 50-10-320 7/6/84 Cal:350EMASS: 206.944



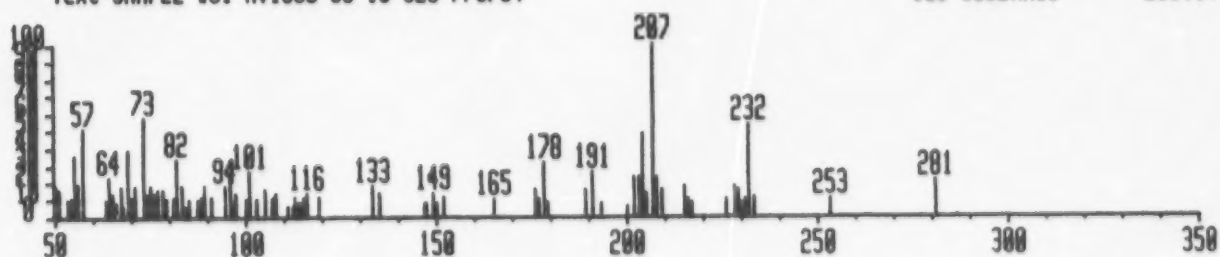
R91#1093+ x1 Bgd=849 6-JUL-84 12:02+0:22:00 12250 EI+
BpM=0 I=22mv Hm=0 TIC=933000 Acnt:GUELPH Sys:350E HMR: 145000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 57.065



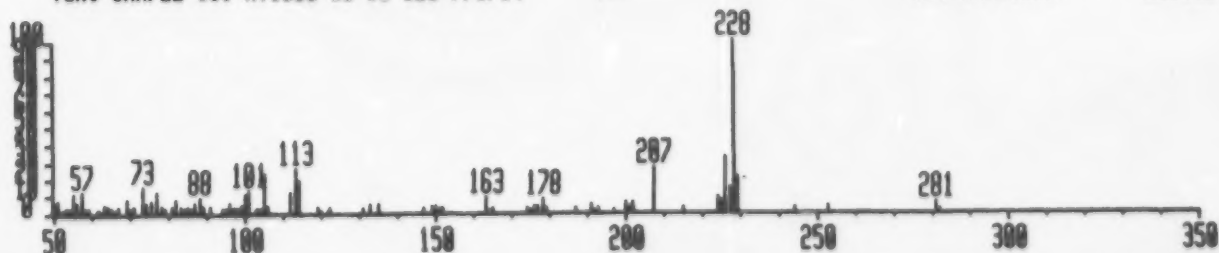
R91#1109+ x1 Bgd=849 6-JUL-84 12:02+0:22:27 12250 EI+
BpM=0 I=10mv Hm=0 TIC=1083000 Acnt:GUELPH Sys:350E HMR: 68000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 232.300



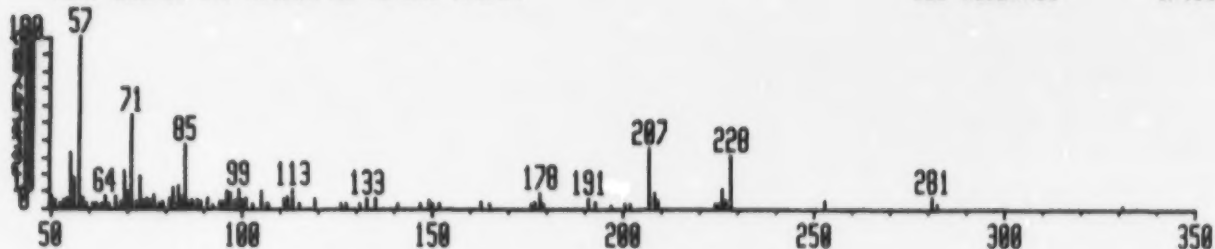
R91#1120+ x1 Bgd=849 6-JUL-84 12:02+0:22:40 12250 EI+
BpM=0 I=8.4mv Hm=0 TIC=774000 Acnt:GUELPH Sys:350E HMR: 55000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.941



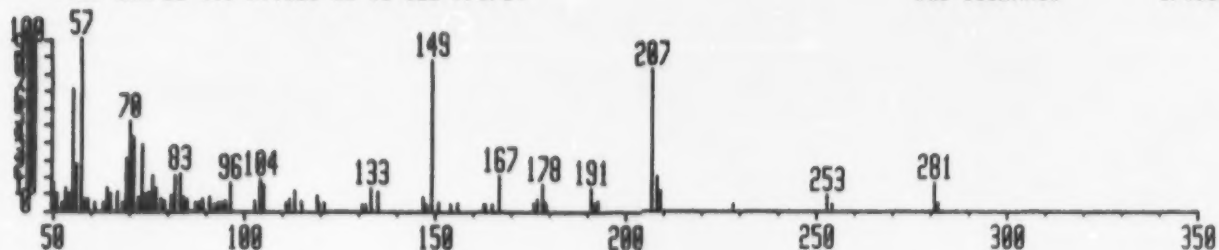
R91#1134+ x1 Bgd=849 6-JUL-84 12:02+0:22:57 12250 EI+
BpM=0 I=30mv Hm=0 TIC=1490000 Acnt:GUELPH Sys:350E HMR: 250000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 220.895



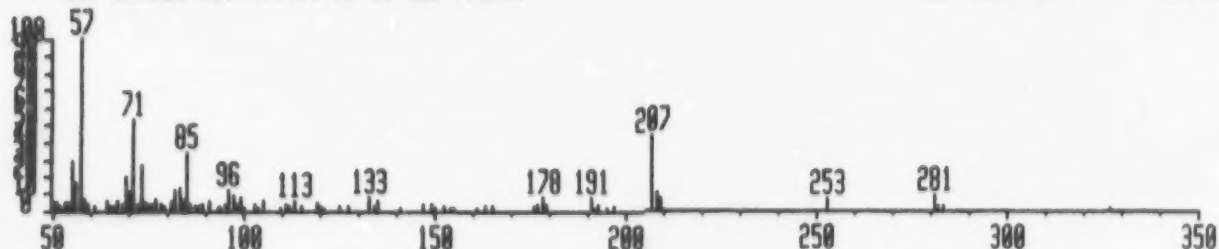
R9101137* x1 Bgd=049 6-JUL-84 12:02:0:23:01 12250 EI+
BpM=0 I=29mv Hm=0 TIC=1388000 Acnt:GUELPH Sys:350E HMR: 196000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 57.065



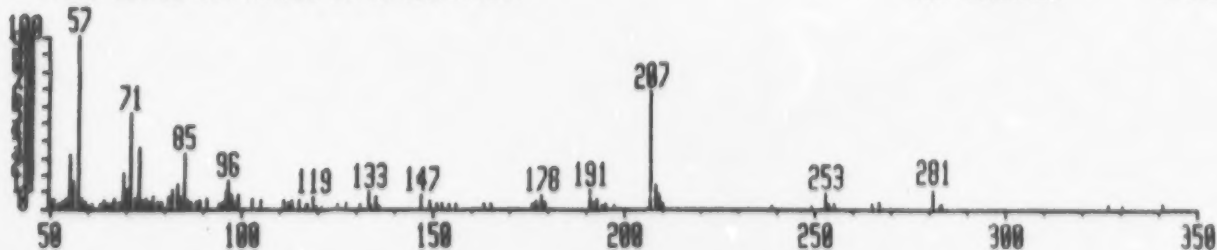
R9101162* x1 Bgd=049 6-JUL-84 12:02:0:23:31 12250 EI+
BpM=0 I=16mv Hm=0 TIC=1188000 Acnt:GUELPH Sys:350E HMR: 107000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 57.062



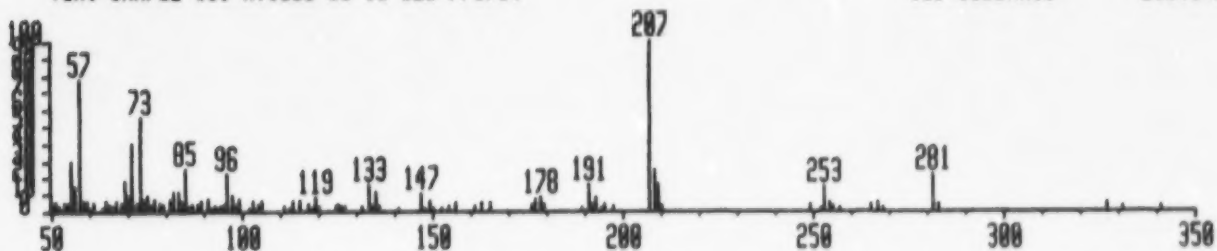
R9101179* x1 Bgd=049 6-JUL-84 12:02:0:23:51 12250 EI+
BpM=0 I=33mv Hm=0 TIC=1304000 Acnt:GUELPH Sys:350E HMR: 221000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 57.079



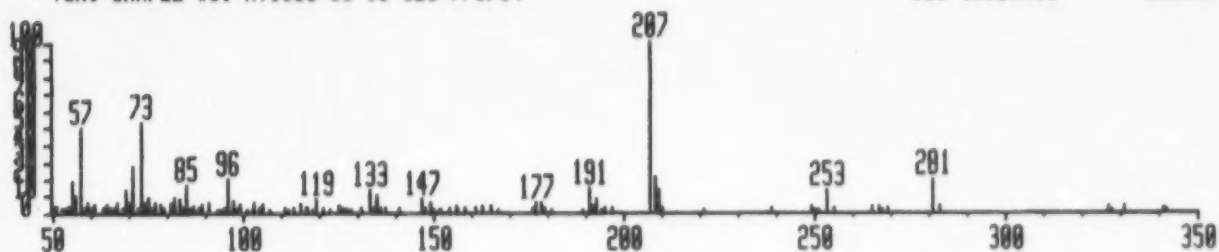
R9101220* x1 Bgd=049 6-JUL-84 12:02:0:24:41 12250 EI+
BpM=0 I=33mv Hm=0 TIC=1622000 Acnt:GUELPH Sys:350E HMR: 216000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 57.060



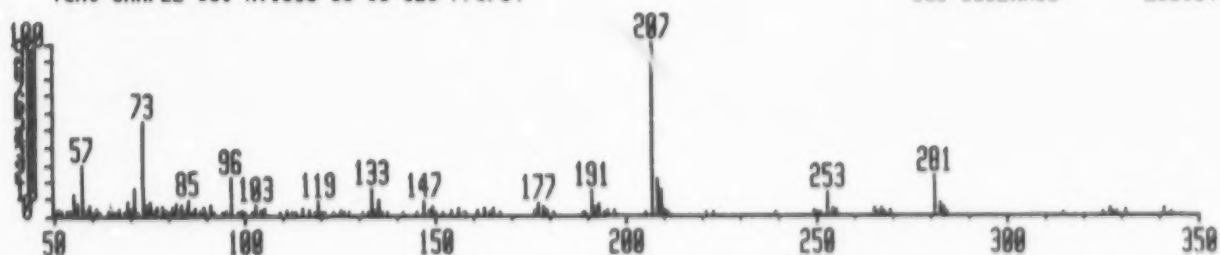
R91#1260* x1 Bgd=049 6-JUL-84 12:02:0:25:29 12250 EI+
BpM=0 I=32mv Hm=0 TIC=1754000 Acnt:GUELPH Sys:350E HMR: 210000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.942



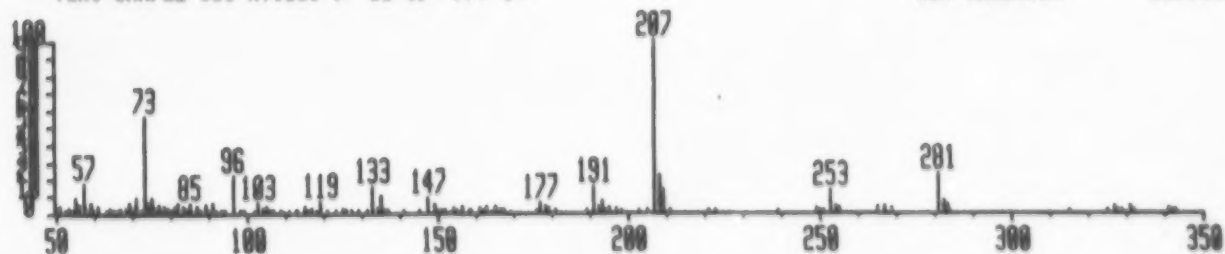
R91#1290* x1 Bgd=049 6-JUL-84 12:02:0:26:15 12250 EI+
BpM=0 I=47mv Hm=0 TIC=2205000 Acnt:GUELPH Sys:350E HMR: 313000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.955



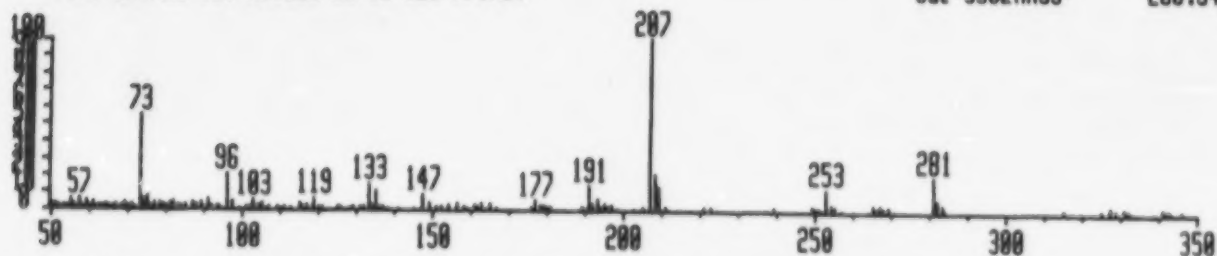
R91#1335* x1 Bgd=049 6-JUL-84 12:02:0:27:00 12250 EI+
BpM=0 I=63mv Hm=0 TIC=2660000 Acnt:GUELPH Sys:350E HMR: 419000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.941



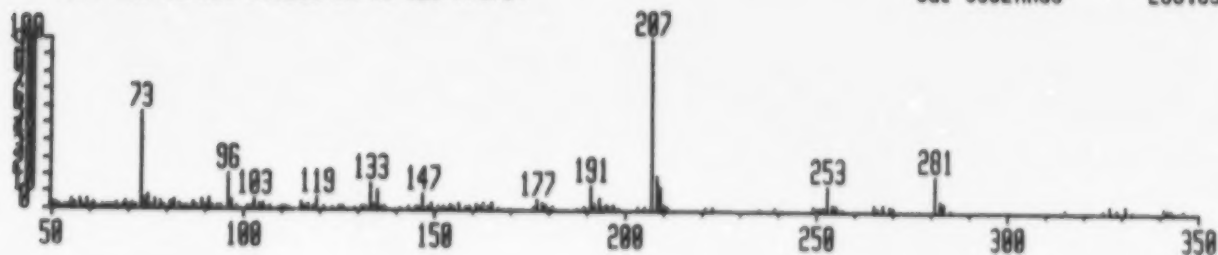
R91#1371* x1 Bgd=049 6-JUL-84 12:02:0:27:43 12250 EI+
BpM=0 I=88mv Hm=0 TIC=3444000 Acnt:GUELPH Sys:350E HMR: 502000
Text: SAMPLE #91 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.939



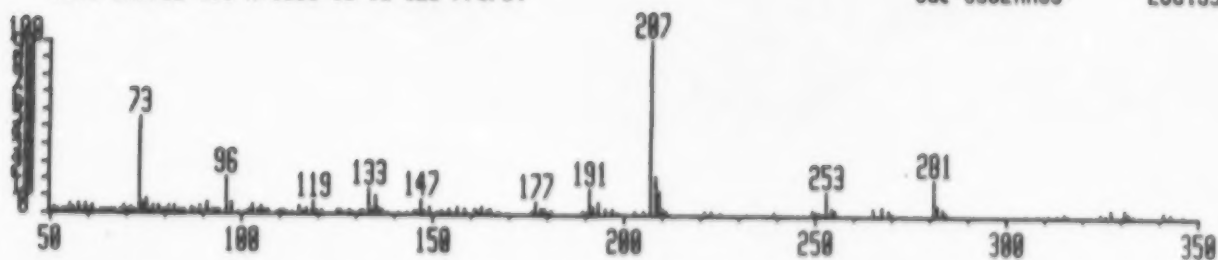
R9101460* x1 Bgd=049 6-JUL-84 12:02:0:29:31 12250 EI+
BpM=0 I=124mv Hm=0 TIC=4325000 Acnt:GUELPH Sys:350E HMR: 014000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.941



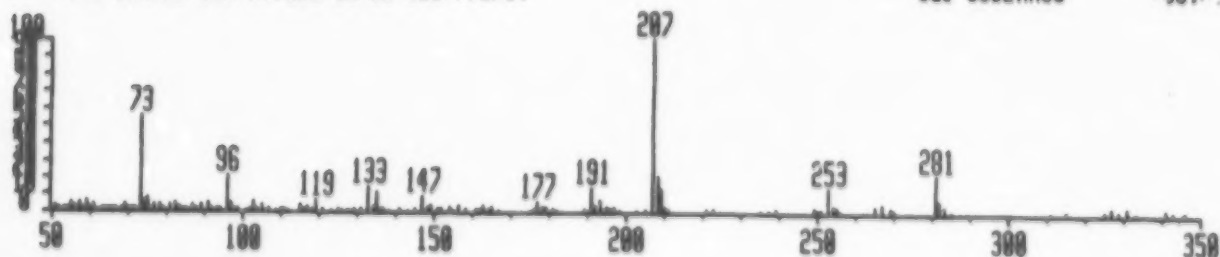
R9101533* x1 Bgd=049 6-JUL-84 12:02:0:30:59 12250 EI+
BpM=0 I=132mv Hm=0 TIC=4611000 Acnt:GUELPH Sys:350E HMR: 070000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.936



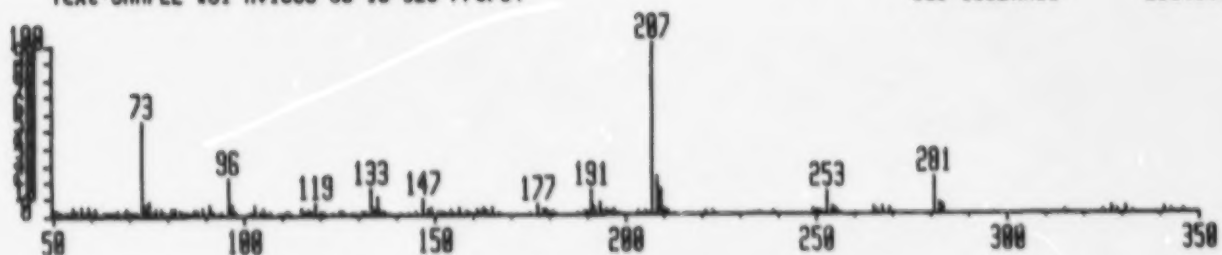
R9101549* x1 Bgd=049 6-JUL-84 12:02:0:31:10 12250 EI+
BpM=0 I=135mv Hm=0 TIC=4661000 Acnt:GUELPH Sys:350E HMR: 009000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.939



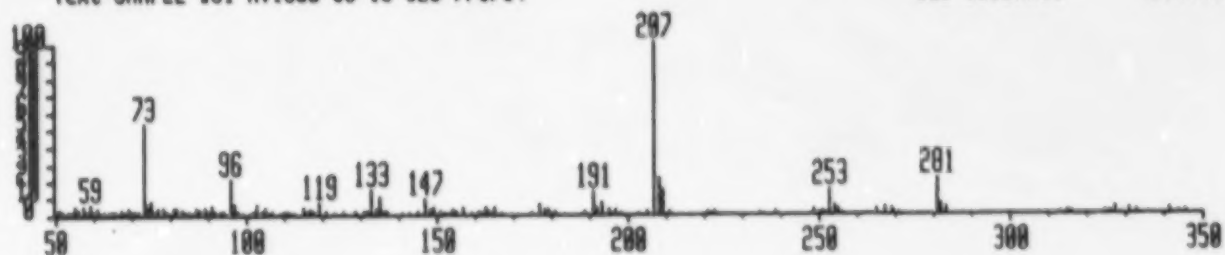
R9101570* x1 Bgd=049 6-JUL-84 12:02:0:31:53 12250 EI+
BpM=0 I=130mv Hm=0 TIC=4703000 Acnt:GUELPH Sys:350E HMR: 905000
Text: SAMPLE 091 MV1600 50-10-320 7/6/84 Cal:350EMASS: 206.930



R9101595* x1 Bgd=049 6-JUL-04 12:02:0:32:14 12250 EI+
BpM=0 I=136mv Hm=0 TIC=4777000 Acnt: GUELPH Sys: 350E HMR: 896000
Text: SAMPLE 091 MV1600 50-10-320 7/6/04 Cal: 350EMASS: 206.930



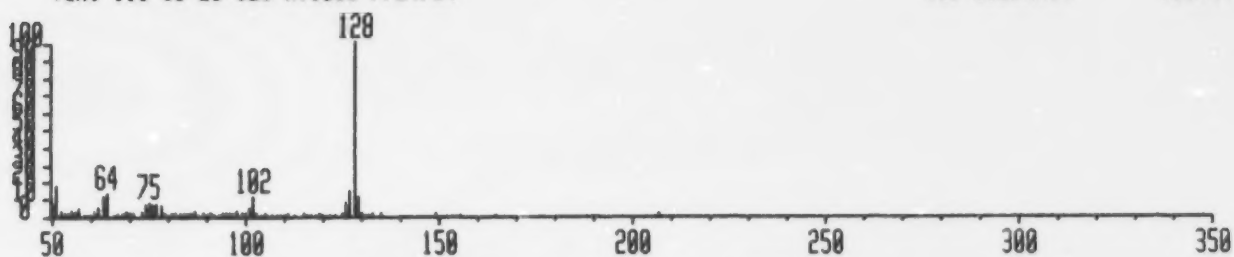
R9101679* x1 Bgd=049 6-JUL-04 12:02:0:33:55 12250 EI+
BpM=0 I=147mv Hm=0 TIC=4981000 Acnt: GUELPH Sys: 350E HMR: 964000
Text: SAMPLE 091 MV1600 50-10-320 7/6/04 Cal: 350EMASS: 206.896



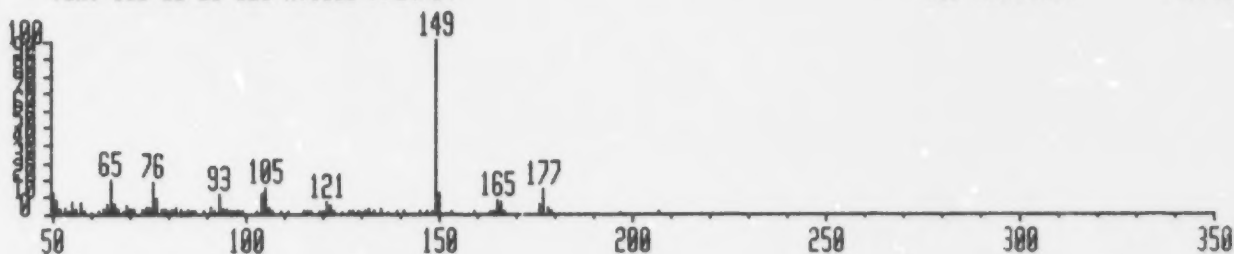
APPENDIX IV

Mass spectrum of FHP Products
of Chrysene, ref: table 20

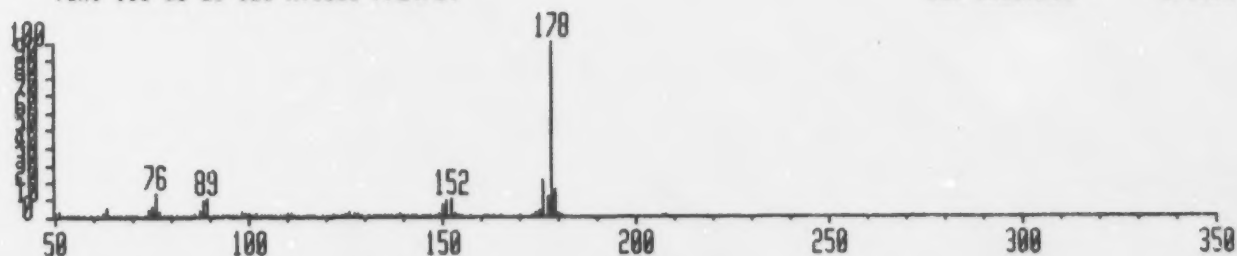
2R110#260* x1 Bgd=1 24-JUL-84 20:27:0:05:19 12250 EI+
 BpM=128 I=234mv Hm=206 TIC=4496000 Acnt: GUELPH Sys: 350E HMR: 1536000
 Text: 110 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 128.047



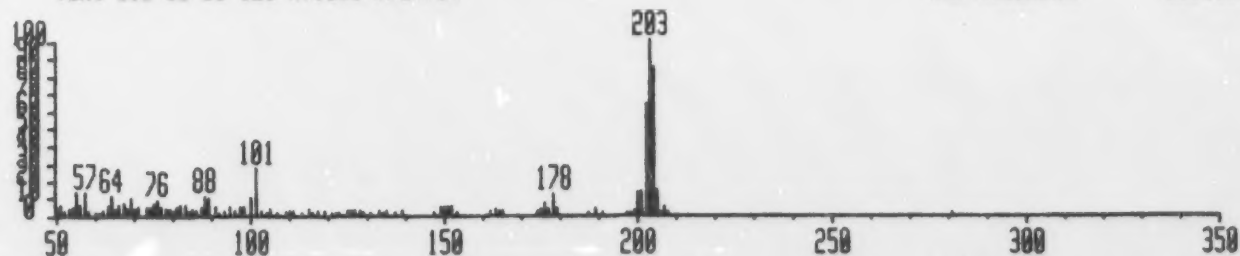
2R110#416* x1 Bgd=1 24-JUL-84 20:27:0:00:20 12250 EI+
 BpM=0 I=136mv Hm=0 TIC=3376000 Acnt: GUELPH Sys: 350E HMR: 892000
 Text: 110 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 148.989



2R110#481* x1 Bgd=478 24-JUL-84 20:27:0:09:46 12250 EI+
 BpM=0 I=2.2v Hm=0 TIC=36072000 Acnt: GUELPH Sys: 350E HMR: 14316000
 Text: 110 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 178.123

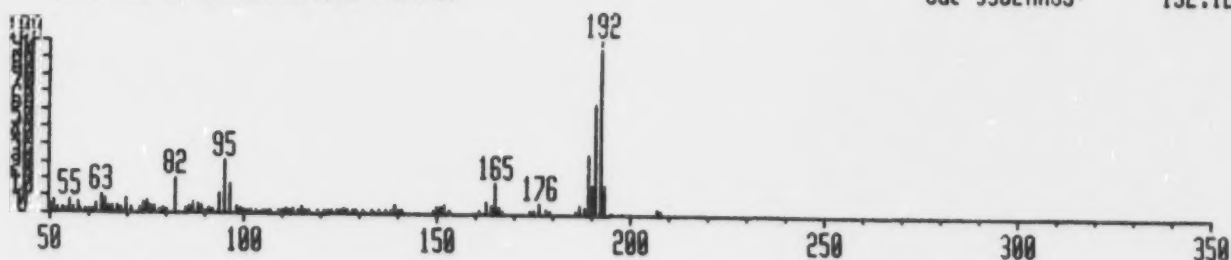


2R110#503* x1 Bgd=478 24-JUL-84 20:27:0:10:13 12250 EI+
 BpM=0 I=5.5mv Hm=0 TIC=2709000 Acnt: GUELPH Sys: 350E HMR: 427000
 Text: 110 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 203.095



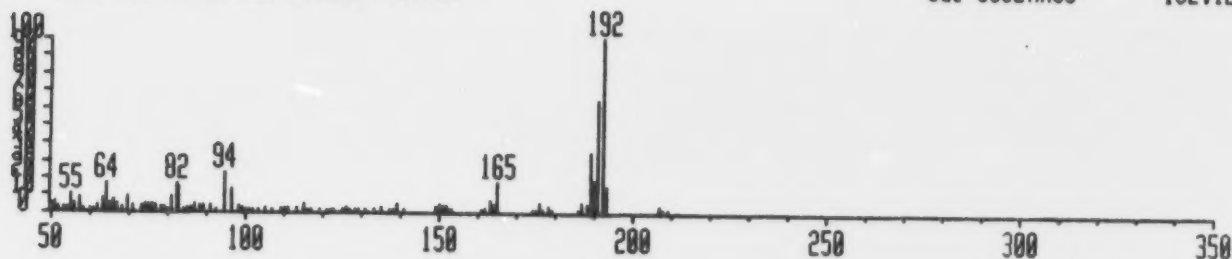
2R110#518* x1 Bgd=478 24-JUL-84 20:27:0:10:31 12250 EI+
BpM=0 I=139mv Hm=0 TIC=4917000 Acnt: GUELPH
Text: 110 50-20-320 MV1600 7/24/84

Sys: 350E HMR: 917000
Cal: 350E MASS: 192.128



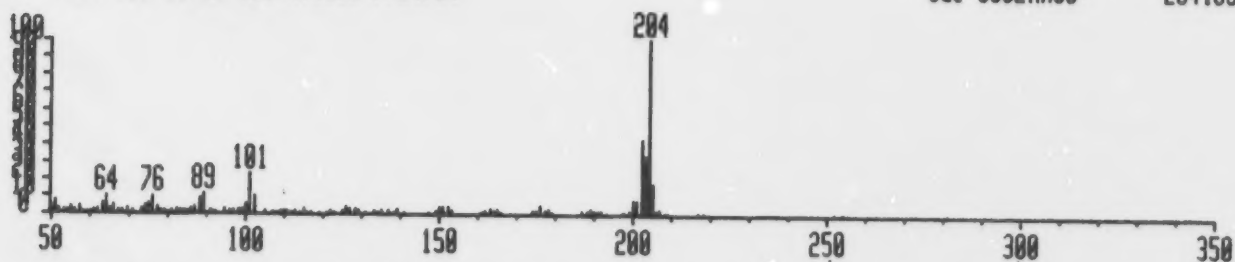
2R110#525* x1 Bgd=478 24-JUL-84 20:27:0:10:39 12250 EI+
BpM=0 I=88mv Hm=0 TIC=3261000 Acnt: GUELPH
Text: 110 50-20-320 MV1600 7/24/84

Sys: 350E HMR: 577000
Cal: 350E MASS: 192.126



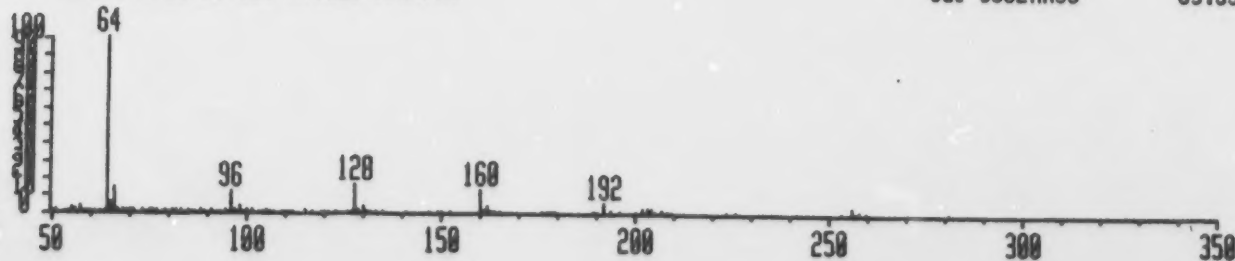
2R110#537* x1 Bgd=478 24-JUL-84 20:27:0:10:54 12250 EI+
BpM=0 I=246mv Hm=0 TIC=6914000 Acnt: GUELPH
Text: 110 50-20-320 MV1600 7/24/84

Sys: 350E HMR: 1615000
Cal: 350E MASS: 204.093

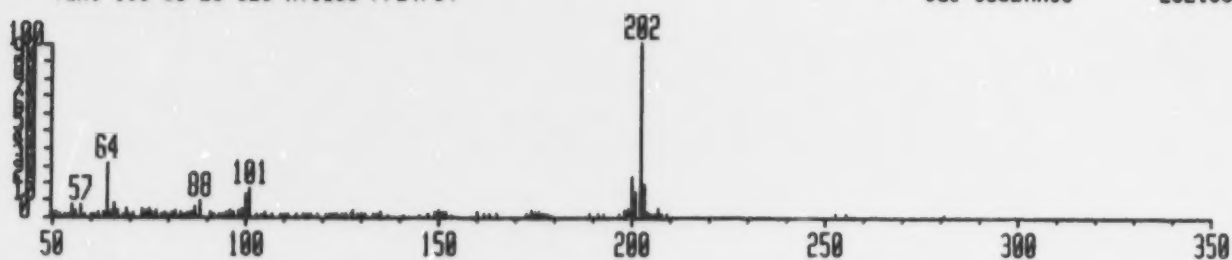


2R110#562* x1 Bgd=478 24-JUL-84 20:27:0:11:24 12250 EI+
BpM=0 I=304mv Hm=0 TIC=5034000 Acnt: GUELPH
Text: 110 50-20-320 MV1600 7/24/84

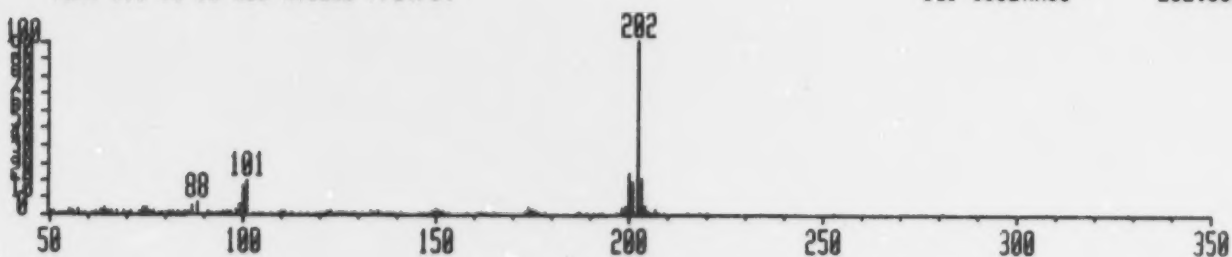
Sys: 350E HMR: 2510000
Cal: 350E MASS: 63.936



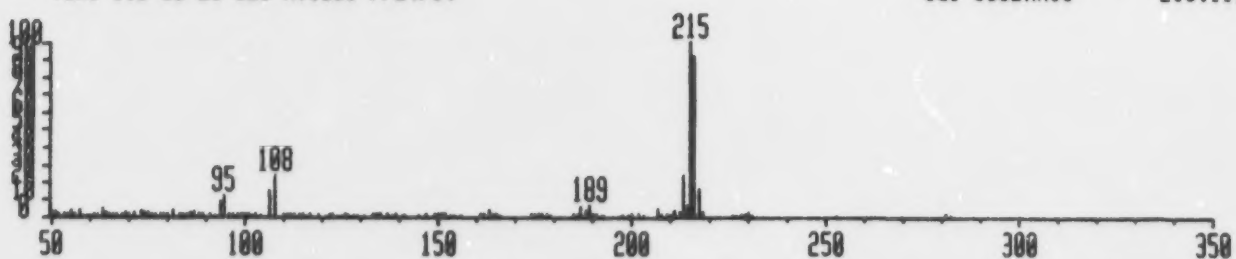
2R110#564* x1 Bgd=470 24-JUL-84 20:27:0:11:27 12250 EI+
 BpM=0 I=119mv Hm=0 TIC=3254000 Acnt:GUELPH Sys:350E HMR: 700000
 Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 202.093



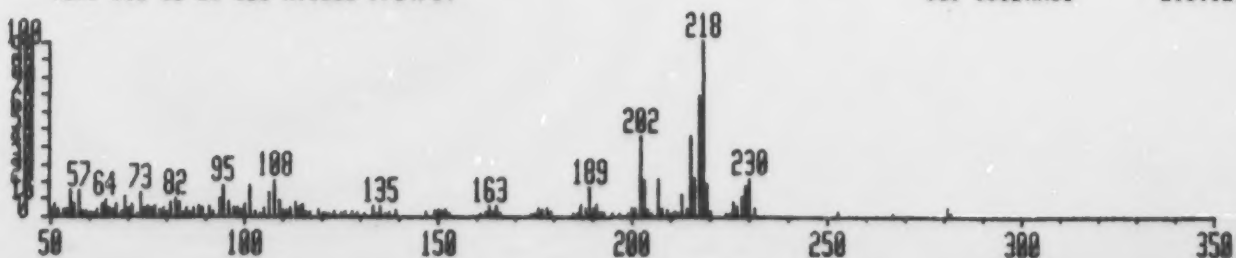
2R110#579* x1 Bgd=470 24-JUL-84 20:27:0:11:45 12250 EI+
 BpM=0 I=409mv Hm=0 TIC=7964000 Acnt:GUELPH Sys:350E HMR: 2604000
 Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 202.086



2R110#600* x1 Bgd=599 24-JUL-84 20:27:0:12:20 12250 EI+
 BpM=0 I=256mv Hm=0 TIC=7348000 Acnt:GUELPH Sys:350E HMR: 1602000
 Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 215.111



2R110#615* x1 Bgd=599 24-JUL-84 20:27:0:12:20 12250 EI+
 BpM=0 I=59mv Hm=0 TIC=3722000 Acnt:GUELPH Sys:350E HMR: 309000
 Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 210.121



2R110#634+ x1 Bgd=599 24-JUL-84 20:27:0:12:51 12250 EI+

BpM=0 I=52mv Hm=0 TIC=3621000

Acnt: GUELPH

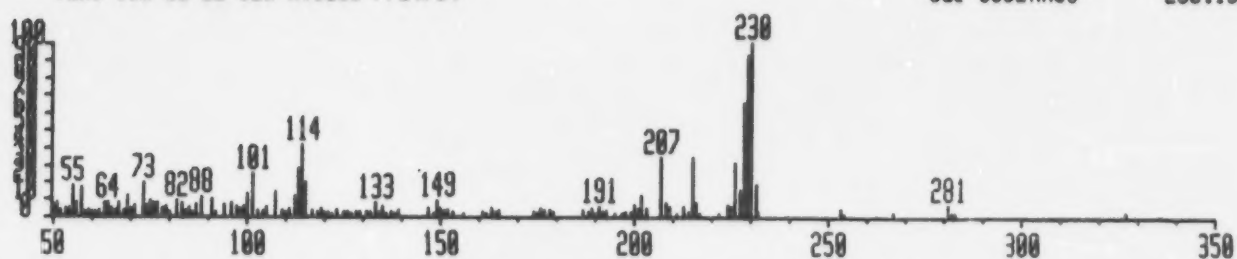
Sys: 350E HMR:

342000

Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

230.137



2R110#638+ x1 Bgd=599 24-JUL-84 20:27:0:12:56 12250 EI+

BpM=0 I=142mv Hm=0 TIC=6542000

Acnt: GUELPH

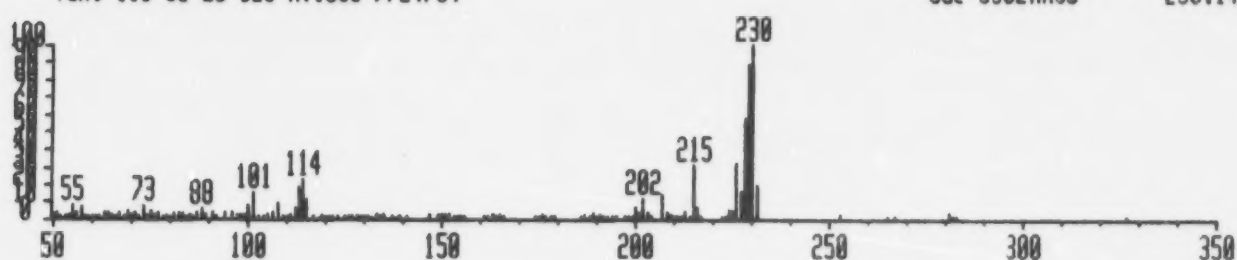
Sys: 350E HMR:

931000

Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

230.142



2R110#649+ x1 Bgd=648 24-JUL-84 20:27:0:13:09 12250 EI+

BpM=0 I=351mv Hm=0 TIC=14896000

Acnt: GUELPH

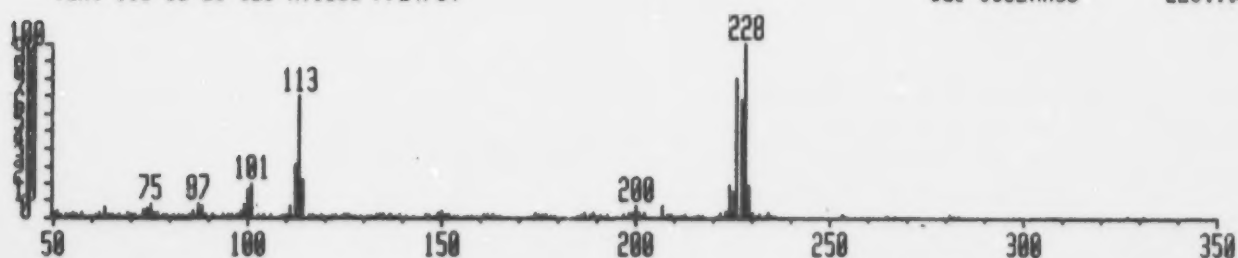
Sys: 350E HMR:

2306000

Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

228.133



2R110#650+ x1 Bgd=648 24-JUL-84 20:27:0:13:20 12250 EI+

BpM=0 I=57mv Hm=0 TIC=4003000

Acnt: GUELPH

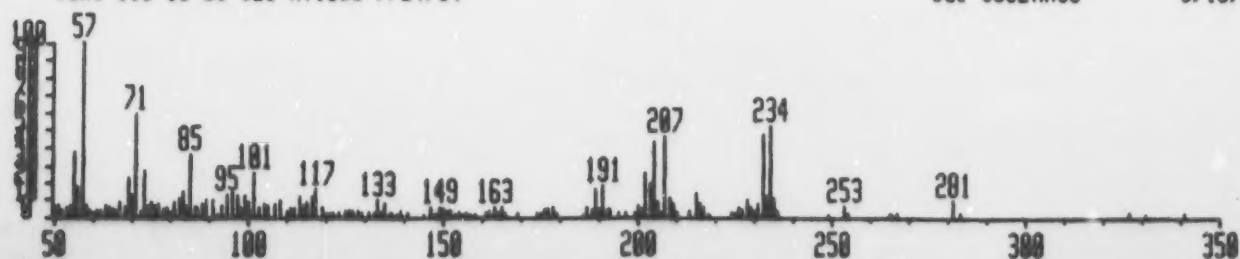
Sys: 350E HMR:

375000

Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

57.073



2R110#663* x1 Bgd=661 24-JUL-84 20:27:0:13:26 12250 EI+

BpM=0 I=964mv Hm=0 TIC=20590000

Acnt: GUELPH

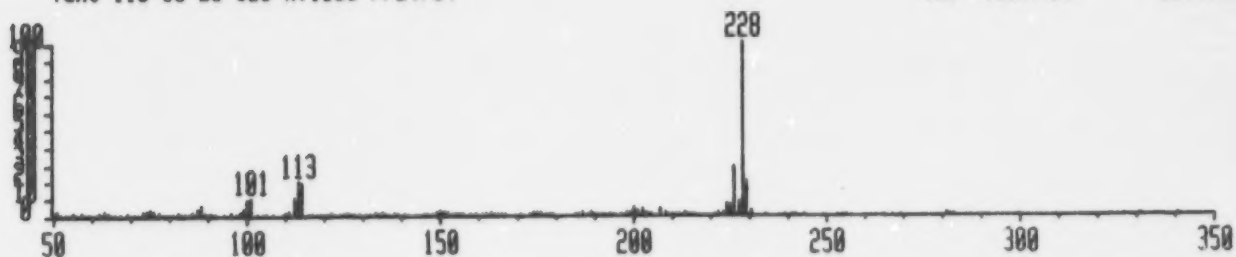
Sys: 350E HMR:

6318000

Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

228.137



2R110#600* x1 Bgd=664 24-JUL-84 20:27:0:13:47 12250 EI+

BpM=0 I=52mv Hm=0 TIC=3916000

Acnt: GUELPH

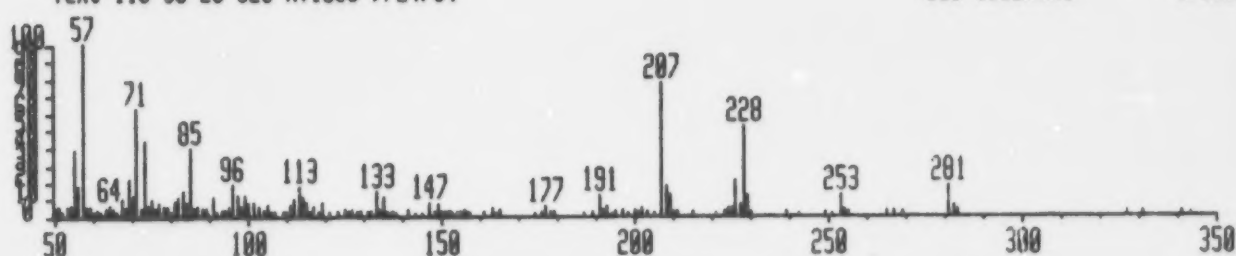
Sys: 350E HMR:

346000

Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

57.000



2R110#694* x1 Bgd=664 24-JUL-84 20:27:0:14:04 12250 EI+

BpM=0 I=223mv Hm=0 TIC=0553000

Acnt: GUELPH

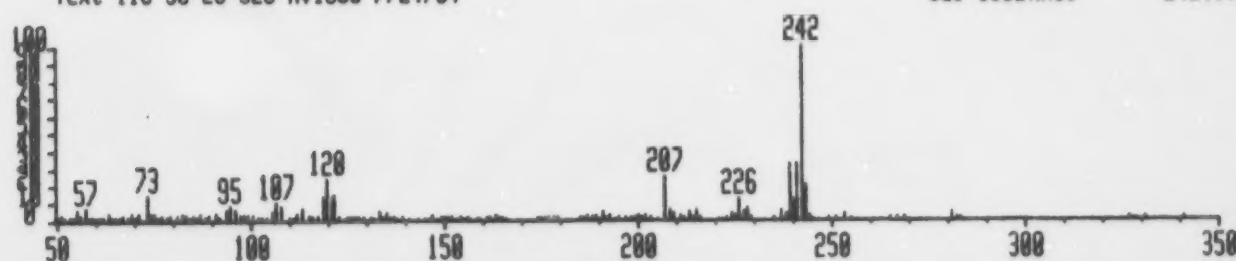
Sys: 350E HMR:

1464000

Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

242.139



2R110#702* x1 Bgd=664 24-JUL-84 20:27:0:14:13 12250 EI+

BpM=0 I=63mv Hm=0 TIC=6574000

Ac: GUELPH

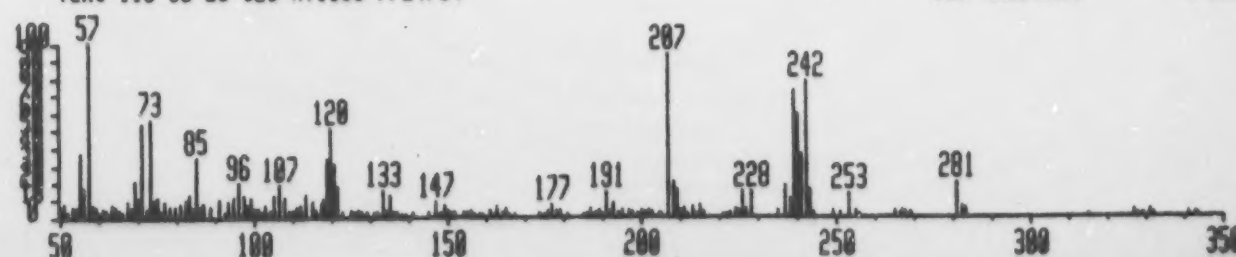
Sys: 350E HMR:

416000

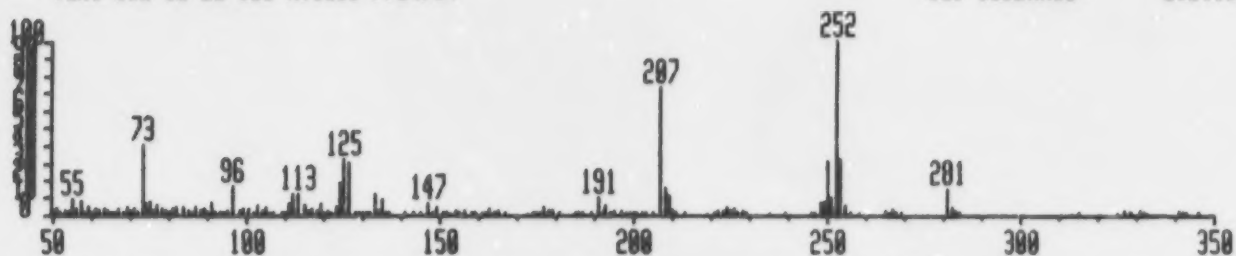
Text: 110 50-20-320 MV1600 7/24/84

Cal: 350EMASS:

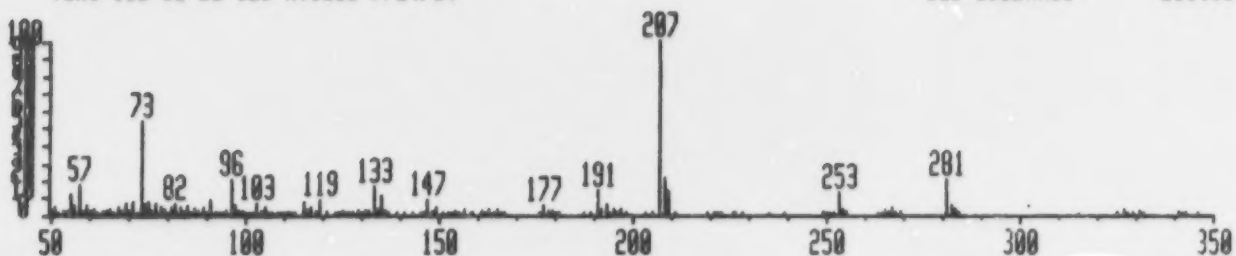
57.076



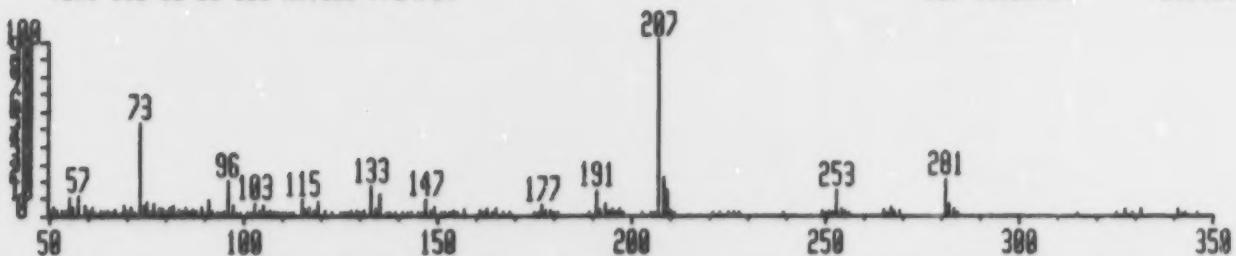
2R1101769* x1 Bgd=664 24-JUL-84 20:27:0:15:34 12250 EI+
BpM=0 I=137mv Hm=0 TIC=7325000 Acnt:GUELPH Sys:350E HMR: 904000
Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 252.136



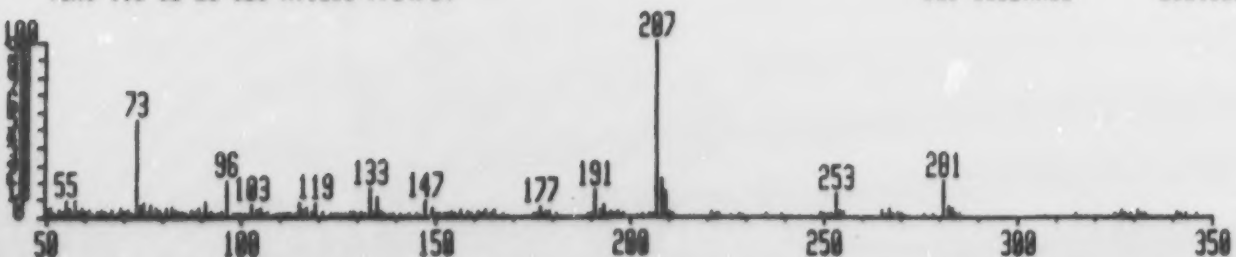
2R1101804* x1 Bgd=664 24-JUL-84 20:27:0:16:16 12250 EI+
BpM=0 I=110mv Hm=0 TIC=4854000 Acnt:GUELPH Sys:350E HMR: 724000
Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 206.930



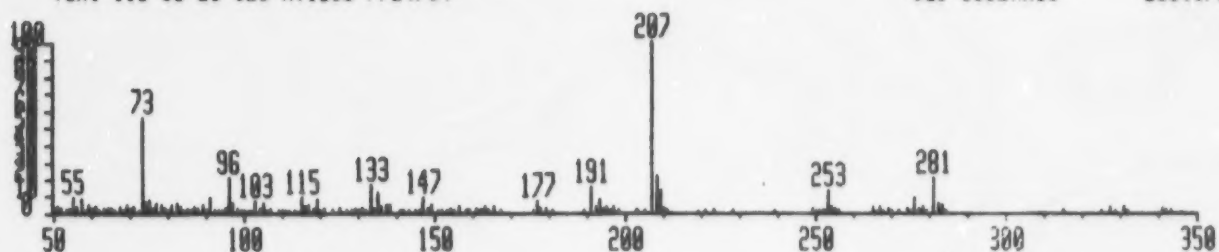
2R1101830* x1 Bgd=664 24-JUL-84 20:27:0:16:57 12250 EI+
BpM=0 I=114mv Hm=0 TIC=4849000 Acnt:GUELPH Sys:350E HMR: 753000
Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 206.806



2R1101867* x1 Bgd=664 24-JUL-84 20:27:0:17:32 12250 EI+
BpM=0 I=117mv Hm=0 TIC=4999000 Acnt:GUELPH Sys:350E HMR: 772000
Text:110 50-20-320 MV1600 7/24/84 Cal:350EMASS: 206.963



2R1101091* x1 Bgd=664 24-JUL-84 20 27-0 18 01 12250 E1+
BpM=0 I=120mv Hm=0 TIC=5221000 Acnt: GUELPH Sys: 350E HMR: 788000
Text: 110 50-20-320 MV1600 7/24/84 Cal: 350E MASS: 206.978



APPENDIX V

Mass Spectrum of Products
Detected in FHP of
Perylene, ref: table 22

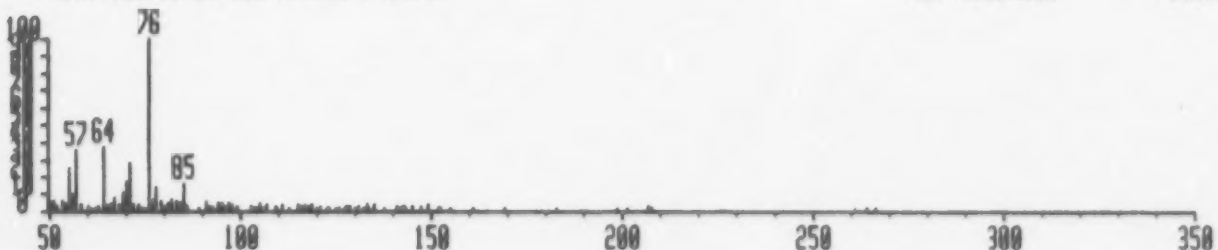
2R10910* x1 Bgd=1 24-JUL-04 19:33:00:15 12250 EI+
BpM=57 I=372mv Hm=346 TIC=5700000 Acnt: GUELPH Sys: 350E HMR: 2440000
Text: 109 50-20-320 MV1600 7/24/04 Cal: 350EMASS: 57.134



2R109134* x1 Bgd=1 24-JUL-04 19:33:00:46 12250 EI+
BpM=76 I=52mv Hm=275 TIC=1756000 Acnt: GUELPH Sys: 350E HMR: 341000
Text: 109 50-20-320 MV1600 7/24/04 Cal: 350EMASS: 75.883



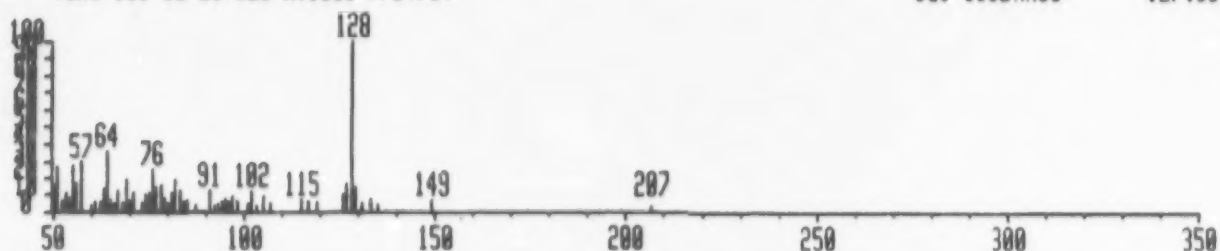
2R109136* x1 Bgd=1 24-JUL-04 19:33:00:49 12250 EI+
BpM=76 I=51mv Hm=266 TIC=1752000 Acnt: GUELPH Sys: 350E HMR: 340000
Text: 109 50-20-320 MV1600 7/24/04 Cal: 350EMASS: 75.869



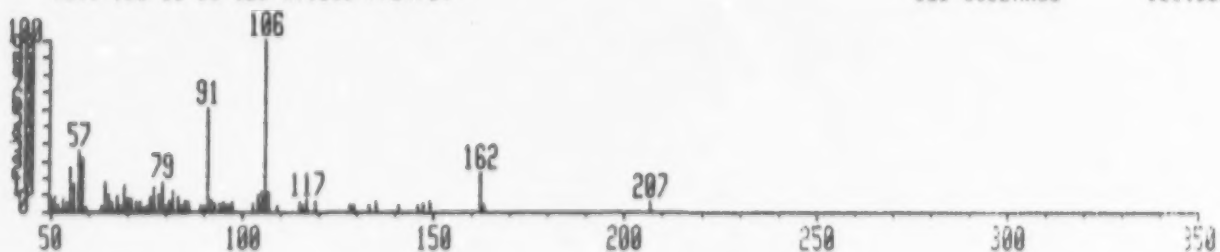
2R109144* x1 Bgd=1 24-JUL-04 19:33:00:50 12250 EI+
BpM=91 I=125mv Hm=260 TIC=3313000 Acnt: GUELPH Sys: 350E HMR: 824000
Text: 109 50-20-320 MV1600 7/24/04 Cal: 350EMASS: 91.019



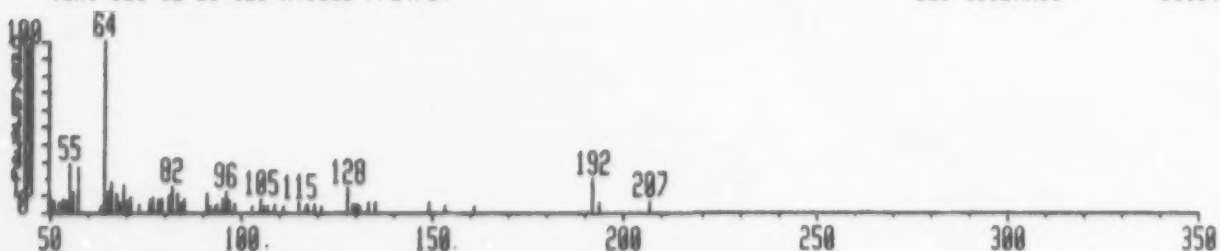
2R109#266* x1 Bgd=1 24-JUL-84 19:33:0:05:27 12250 EI+
BpM=128 I=17mv Hm=206 TIC=781000 Acnt: GUELPH Sys: 350E HMR: 117000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 127.991



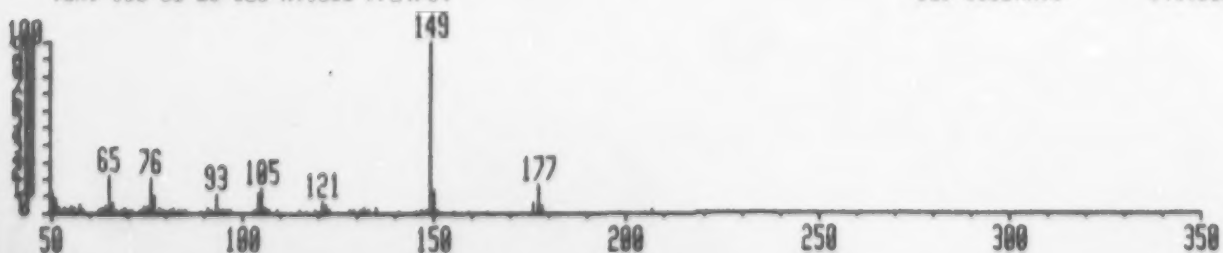
2R109#365* x1 Bgd=1 24-JUL-84 19:33:0:07:26 12250 EI+
BpM=106 I=24mv Hm=206 TIC=1071000 Acnt: GUELPH Sys: 350E HMR: 163000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 105.967



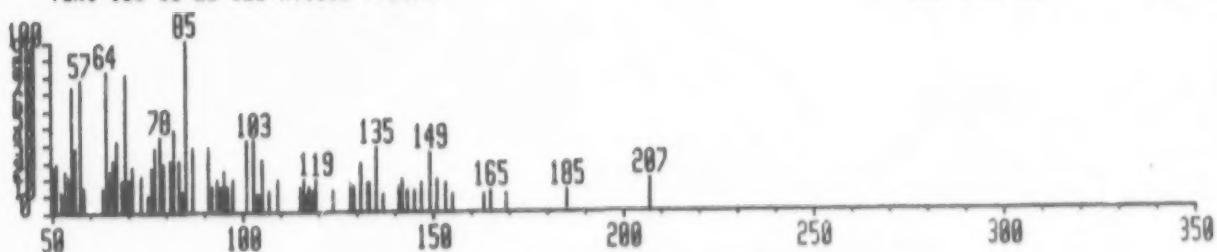
2R109#393* x1 Bgd=1 24-JUL-84 19:33:0:08:00 12250 EI+
BpM=64 I=22mv Hm=206 TIC=756000 Acnt: GUELPH Sys: 350E HMR: 144000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 63.945



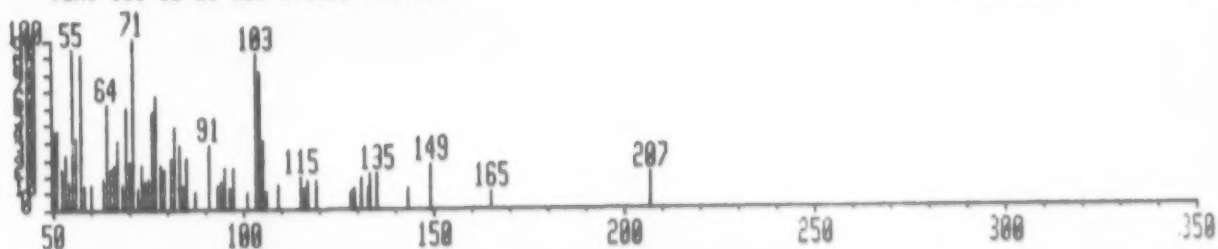
2R109#417* x1 Bgd=1 24-JUL-84 19:33:0:08:29 12250 EI+
BpM=149 I=160mv Hm=206 TIC=3499000 Acnt: GUELPH Sys: 350E HMR: 1050000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 149.006



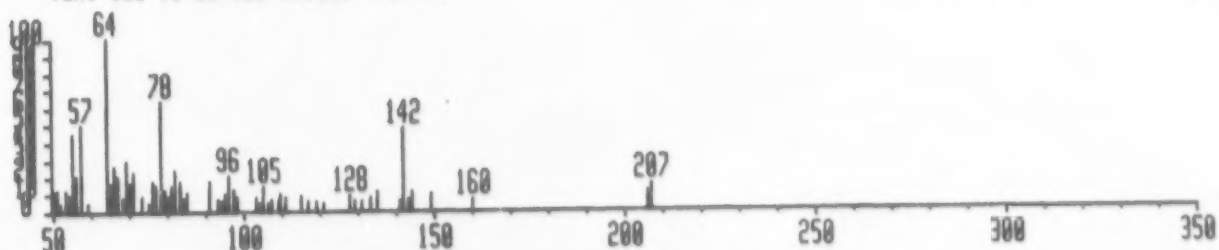
2R109#437* x1 Bgd=1 24-JUL-84 19:33:00:53 12250 EI+
 BpM=85 I=6.7mv Hm=206 TIC=796000 Acnt: GUELPH Sys: 350E HMR: 44000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 84.947



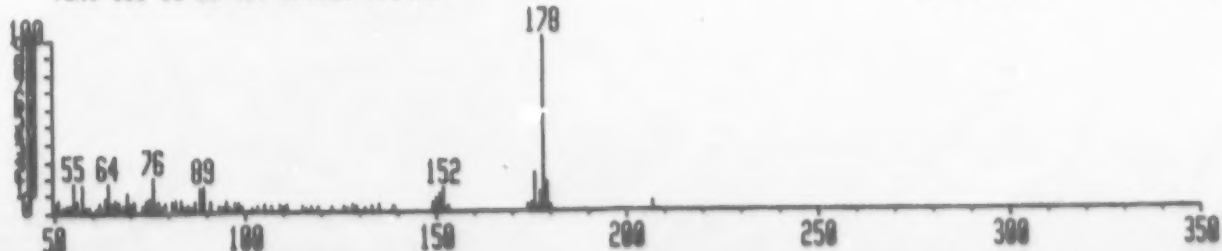
2R109#440* x1 Bgd=1 24-JUL-84 19:33:00:06 12250 EI+
 BpM=71 I=6.7mv Hm=206 TIC=782000 Acnt: GUELPH Sys: 350E HMR: 44000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 71.053



2R109#466* x1 Bgd=1 24-JUL-84 19:33:00:20 12250 EI+
 BpM=64 I=13mv Hm=206 TIC=833000 Acnt: GUELPH Sys: 350E HMR: 91000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 63.953



2R109#483* x1 Bgd=1 24-JUL-84 19:33:00:49 12250 EI+
 BpM=178 I=47mv Hm=206 TIC=1530000 Acnt: GUELPH Sys: 350E HMR: 110000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 178.129



2R1090520* x1 Bgd=1 24-JUL-84 19:33:0:10:43 12250 EI+

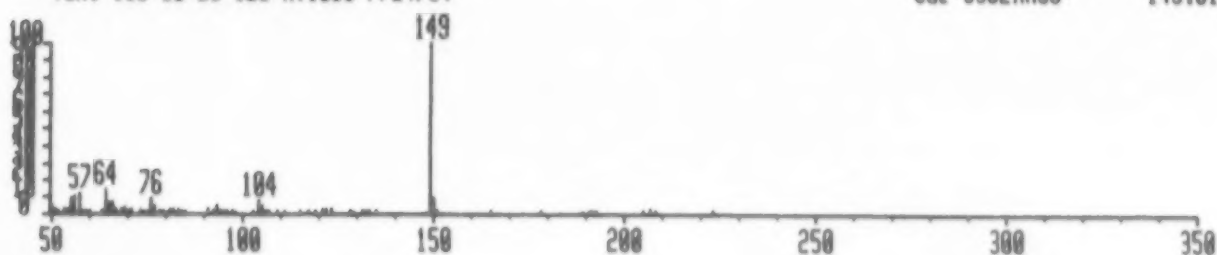
BpM=149 I=120mv Hm=223 TIC=2302000

Acnt:GUELPH

Sys:350E HMR: 840000

Text:109 50-20-320 MV1600 7/24/84

Cal:350EMASS: 149.011



2R1090562* x1 Bgd=1 24-JUL-84 19:33:0:11:24 12250 EI+

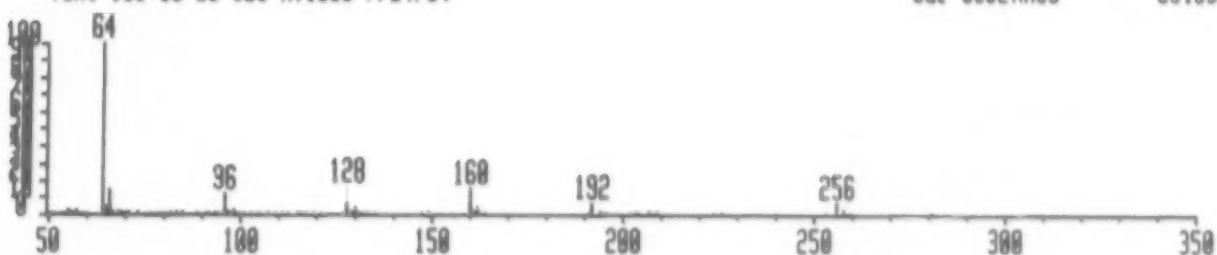
BpM=64 I=496mv Hm=200 TIC=6857000

Acnt:GUELPH

Sys:350E HMR: 3254000

Text:109 50-20-320 MV1600 7/24/84

Cal:350EMASS: 63.953



2R1090580* x1 Bgd=1 24-JUL-84 19:33:0:11:46 12250 EI+

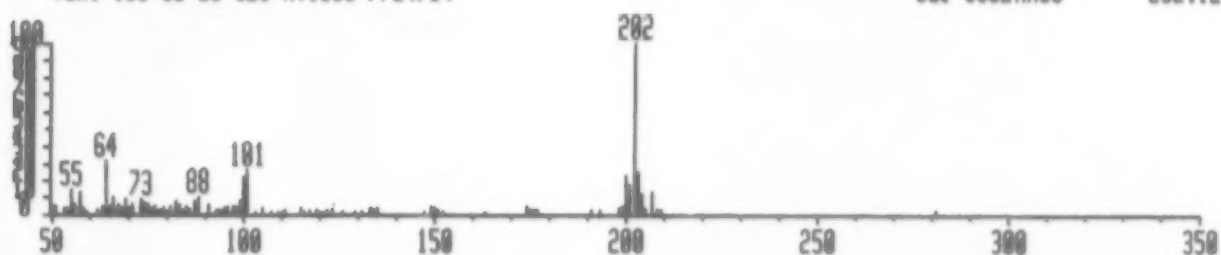
BpM=202 I=51mv Hm=200 TIC=1851000

Acnt:GUELPH

Sys:350E HMR: 335000

Text:109 50-20-320 MV1600 7/24/84

Cal:350EMASS: 202.120



2R1090587* x1 Bgd=1 24-JUL-84 19:33:0:11:54 12250 EI+

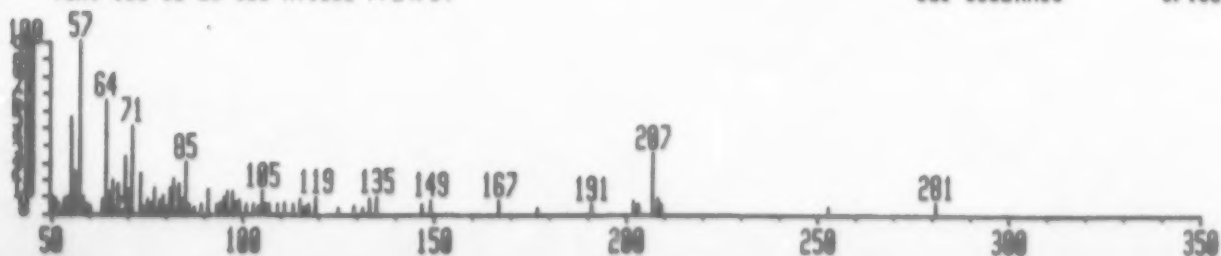
BpM=57 I=10mv Hm=200 TIC=1153000

Acnt:GUELPH

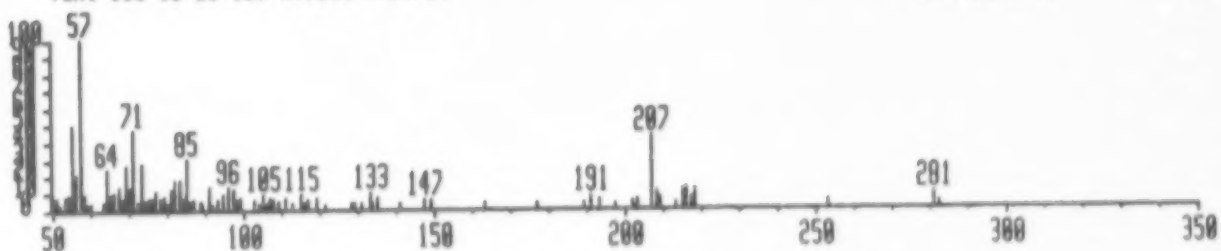
Sys:350E HMR: 122000

Text:109 50-20-320 MV1600 7/24/84

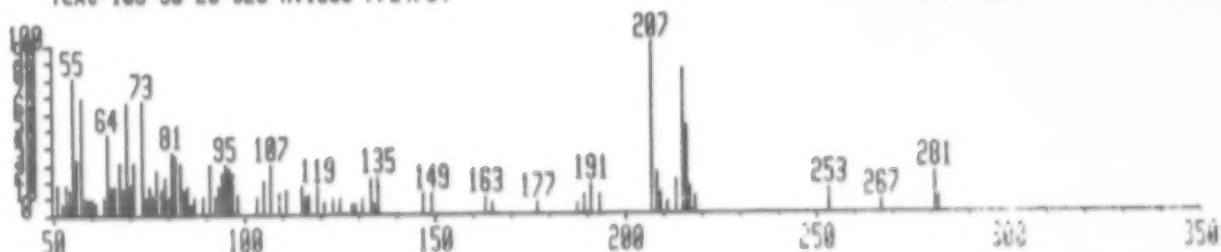
Cal:350EMASS: 57.090



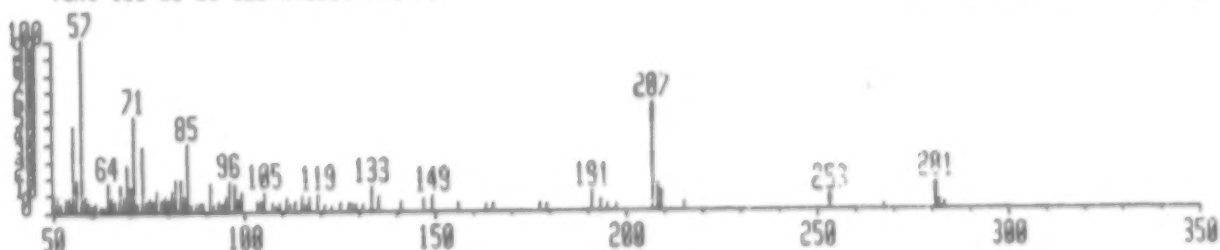
2R1090612* x1 Bgd=1 24-JUL-84 19:33:0 12:24 12250 EI+
 BpM=57 I=24mv Hm=202 TIC=1404000 Acnt GUELPH Sys 350E HMR 162000
 Text: 109 50-20-320 MV1600 7/24/84 Cal 350E MASS 57.876



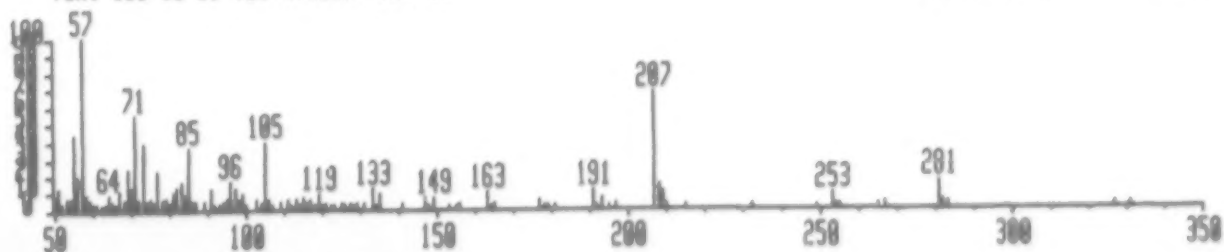
2R1090617* x1 Bgd=1 24-JUL-84 19:33:0 12:30 12250 EI+
 BpM=207 I=11mv Hm=201 TIC=1260000 Acnt GUELPH Sys 350E HMR 75000
 Text: 109 50-20-320 MV1600 7/24/84 Cal 350E MASS 206.947



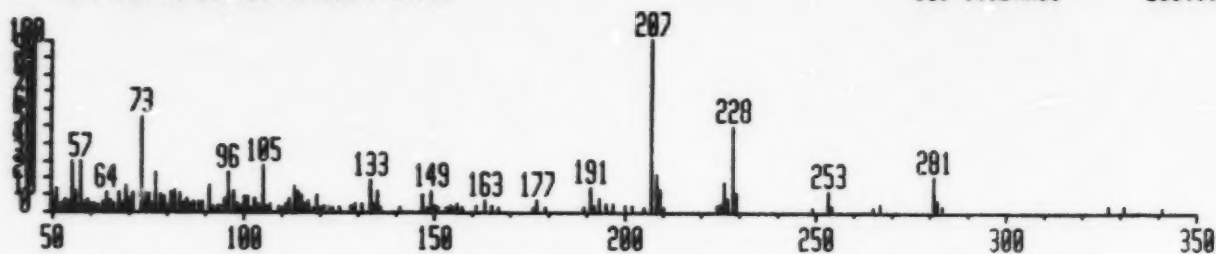
2R1090635* x1 Bgd=1 24-JUL-84 19:33:0 12:52 12250 EI+
 BpM=57 I=24mv Hm=203 TIC=1543000 Acnt GUELPH Sys 350E HMR 158000
 Text: 109 50-20-320 MV1600 7/24/84 Cal 350E MASS 57.892



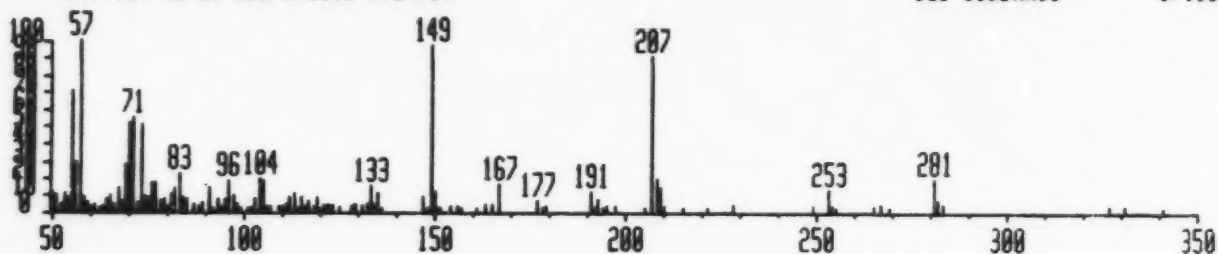
2R1090650* x1 Bgd=1 24-JUL-84 19:33:0 13:20 12250 EI+
 BpM=57 I=38mv Hm=331 TIC=2447000 Acnt GUELPH Sys 350E HMR 253000
 Text: 109 50-20-320 MV1600 7/24/84 Cal 350E MASS 57.886



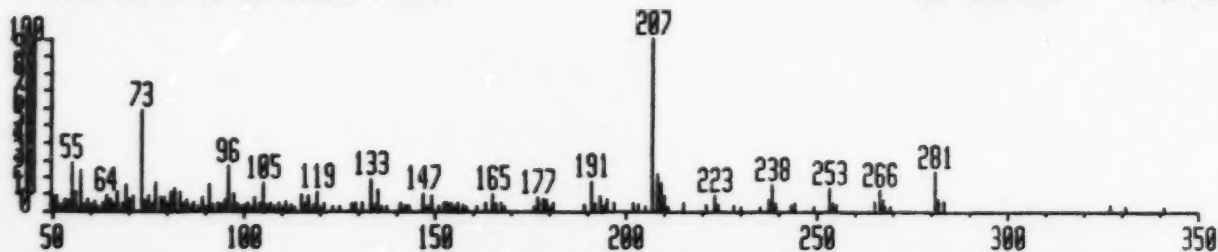
2R1091667* x1 Bgd=1 24-JUL-84 19:33:0:13:31 12250 EI+
BpM=207 I=30mv Hm=340 TIC=2147000 Acnt: GUELPH Sys: 350E HMR: 200000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 206.953



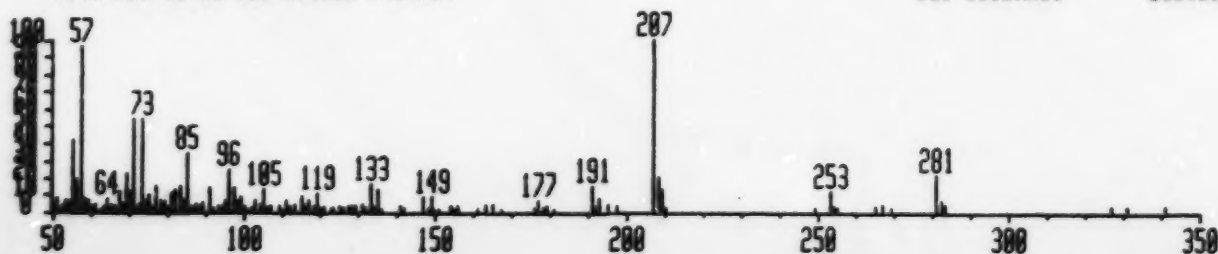
2R1091673* x1 Bgd=1 24-JUL-84 19:33:0:13:38 12250 EI+
BpM=57 I=37mv Hm=341 TIC=3202000 Acnt: GUELPH Sys: 350E HMR: 240000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 57.000



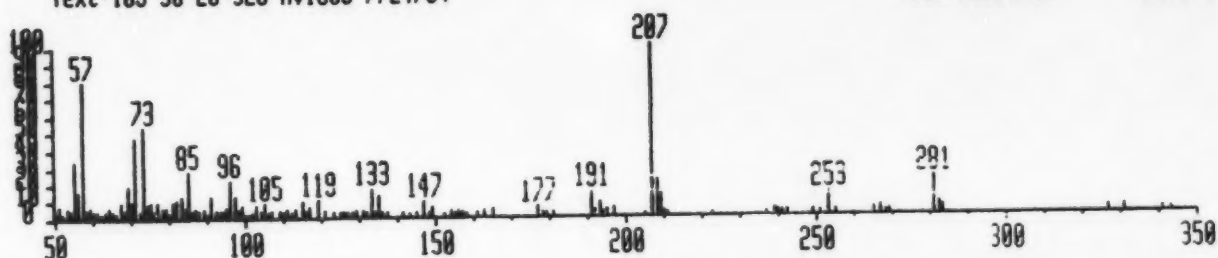
2R1091677* x1 Bgd=1 24-JUL-84 19:33:0:13:43 12250 EI+
BpM=207 I=36mv Hm=340 TIC=2499000 Acnt: GUELPH Sys: 350E HMR: 230000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 206.369



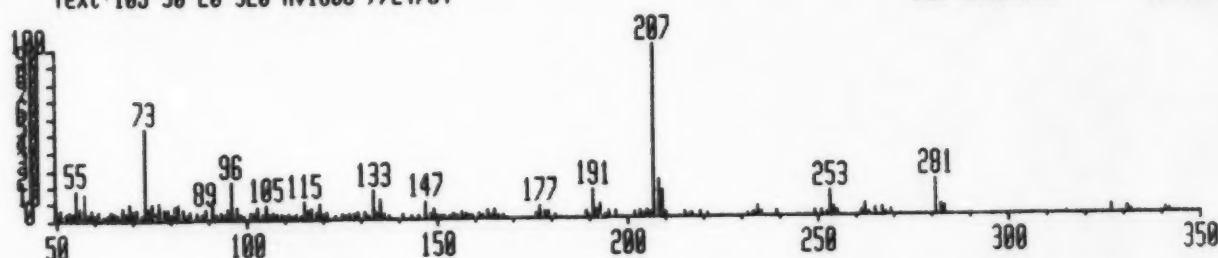
2R1091680* x1 Bgd=1 24-JUL-84 19:33:0:13:47 12250 EI+
BpM=207 I=39mv Hm=340 TIC=2753000 Acnt: GUELPH Sys: 350E HMR: 250000
Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 206.969



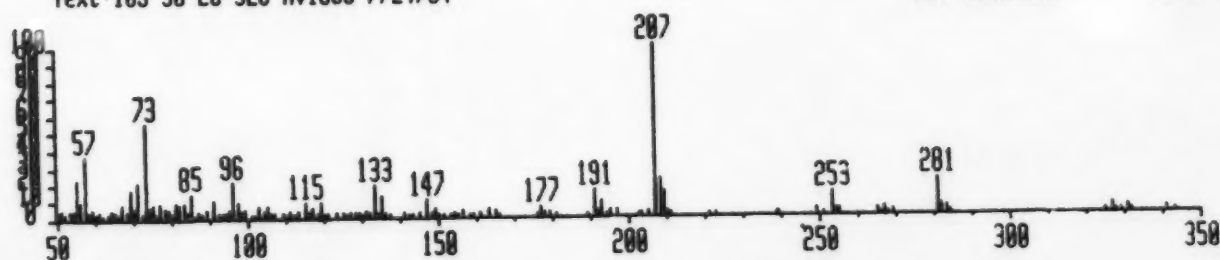
2R1091702* x1 Bgd=1 24-JUL-84 19:33:0:14:13 12250 EI+
 BpM=207 I=57mv Hm=342 TIC=3506000 Acnt: GUELPH Sys: 350E HMR: 375000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 206.947



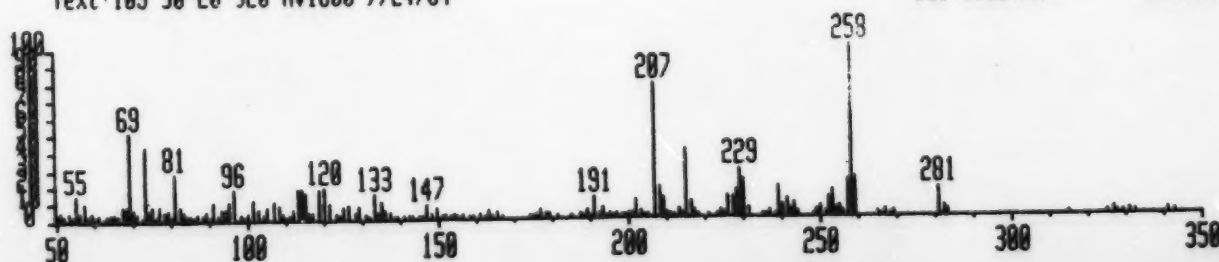
2R1091700* x1 Bgd=1 24-JUL-84 19:33:0:14:20 12250 EI+
 BpM=207 I=60mv Hm=341 TIC=3143000 Acnt: GUELPH Sys: 350E HMR: 398000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 206.955



2R1091724* x1 Bgd=1 24-JUL-84 19:33:0:14:40 12250 EI+
 BpM=207 I=73mv Hm=342 TIC=3064000 Acnt: GUELPH Sys: 350E HMR: 483000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 206.953



2R1091734* x1 Bgd=1 24-JUL-84 19:33:0:14:52 12250 EI+
 BpM=207 I=104mv Hm=342 TIC=0332000 Acnt: GUELPH Sys: 350E HMR: 691000
 Text: 109 50-20-320 MV1600 7/24/84 Cal: 350EMASS: 258.218



2R1090739+ x1 Bgd=1 24-JUL-84 19:33:0:14:50 12250 EI+

BpM=207 I=84mv Hm=343 TIC=4337000

Acnt: GUELPH

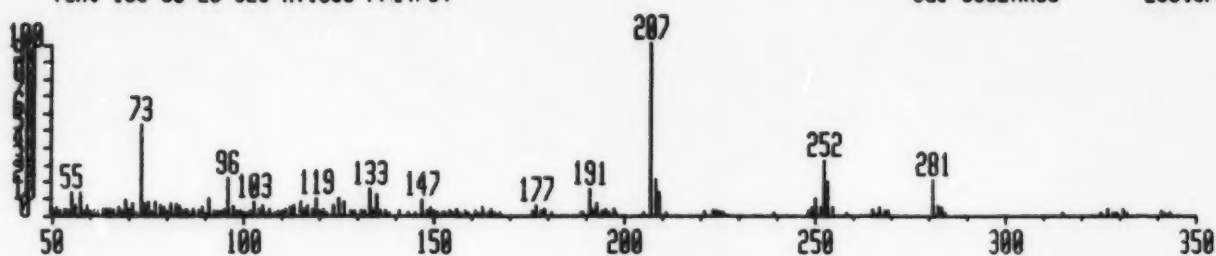
Sys: 350E HMR:

556000

Text: 109 50-20-320 MV1600 7/24/84

Cal: 350E MASS:

206.977



2R1090740+ x1 Bgd=1 24-JUL-84 19:33:0:15:09 12250 EI+

BpM=207 I=90mv Hm=345 TIC=4520000

Acnt: GUELPH

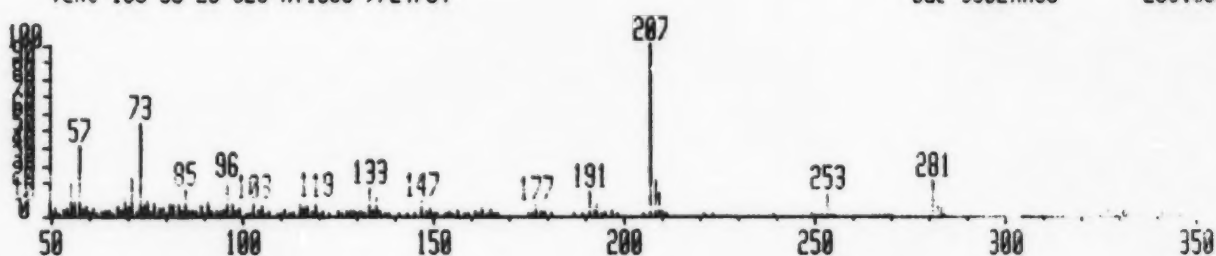
Sys: 350E HMR:

591000

Text: 109 50-20-320 MV1600 7/24/84

Cal: 350E MASS:

206.964



2R1090750+ x1 Bgd=1 24-JUL-84 19:33:0:15:21 12250 EI+

BpM=207 I=94mv Hm=342 TIC=5509000

Acnt: GUELPH

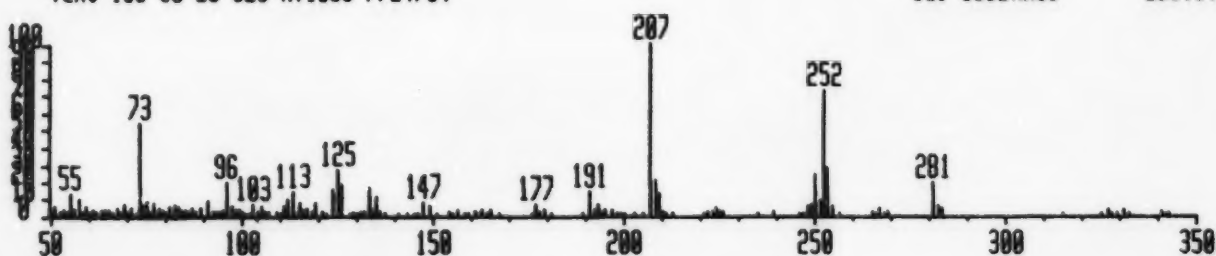
Sys: 350E HMR:

621000

Text: 109 50-20-320 MV1600 7/24/84

Cal: 350E MASS:

206.949



2R1090769+ x1 Bgd=764 24-JUL-84 19:33:0:15:34 12250 EI+

BpM=252 I=10v Hm=342 TIC=201041000

Acnt: GUELPH

Sys: 350E HMR:

655.40%

Text: 109 50-20-320 MV1600 7/24/84

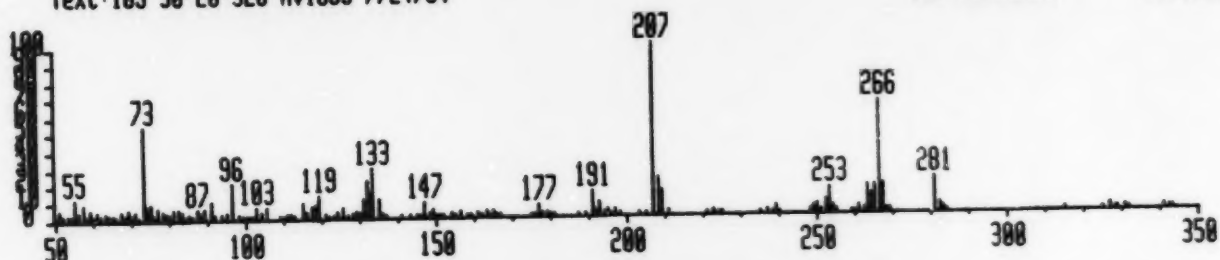
Cal: 350E MASS:

252.204

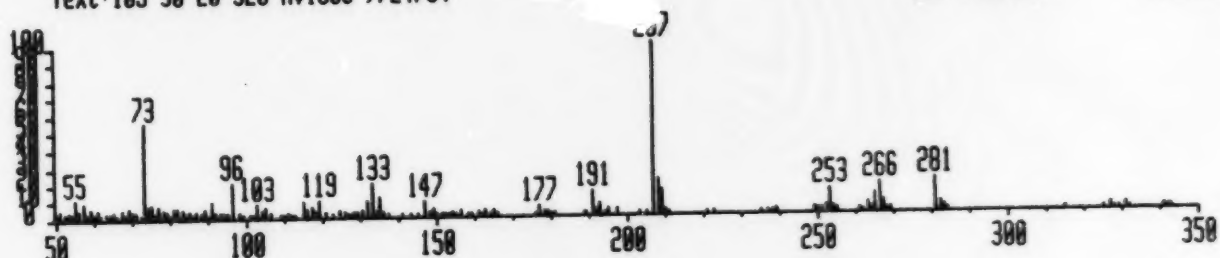


194

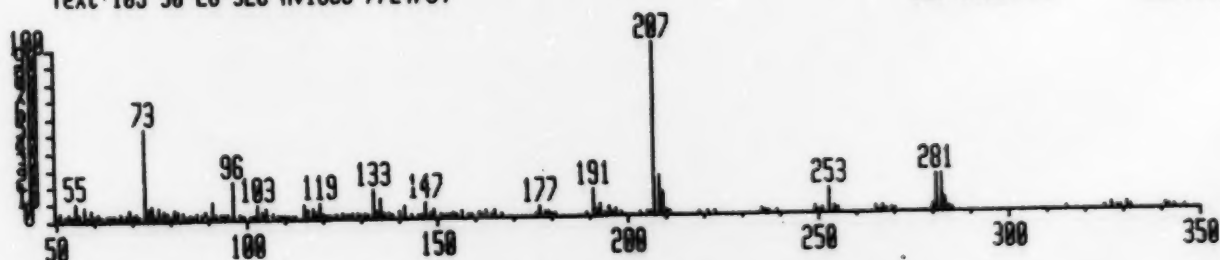
2R1090800+ x1 Bgd=764 24-JUL-84 19:33:0:16:11 12250 EI+
BpM=207 I=98mv Hm=342 TIC=5769000 Acnt:GUELPH Sys:350E HMR: 640000
Text:109 50-20-320 MV1600 7/24/84 Cal:350EMASS: 206.900



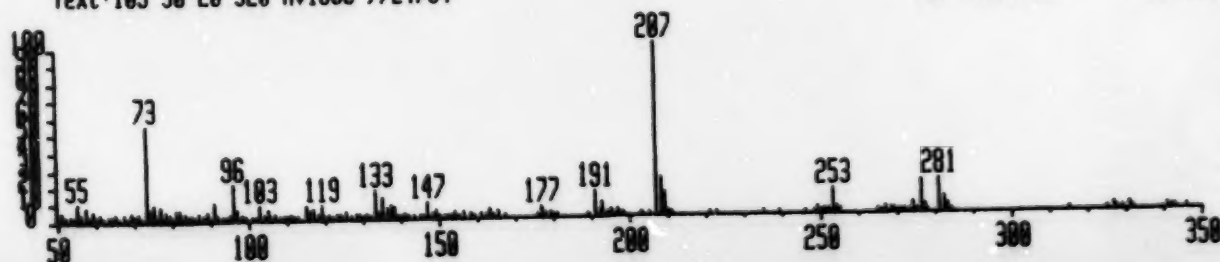
2R1090817+ x1 Bgd=764 24-JUL-84 19:33:0:16:32 12250 EI+
BpM=207 I=102mv Hm=342 TIC=4774000 Acnt:GUELPH Sys:350E HMR: 674000
Text:109 50-20-320 MV1600 7/24/84 Cal:350EMASS: 206.956



2R1090870+ x1 Bgd=764 24-JUL-84 19:33:0:17:46 12250 EI+
BpM=207 I=114mv Hm=345 TIC=5111000 Acnt:GUELPH Sys:350E HMR: 751000
Text:109 50-20-320 MV1600 7/24/84 Cal:350EMASS: 206.963



2R1090887+ x1 Bgd=764 24-JUL-84 19:33:0:17:56 12250 EI+
BpM=207 I=115mv Hm=346 TIC=5341000 Acnt:GUELPH Sys:350E HMR: 751000
Text:109 50-20-320 MV1600 7/24/84 Cal:350EMASS: 206.953



2R109#965* x1 Bgd=764 24-JUL-84 19:33:0:19:31 12250 EI+

BpM=207 I=124mv Hm=346 TIC=5107000

Acnt: GUELPH

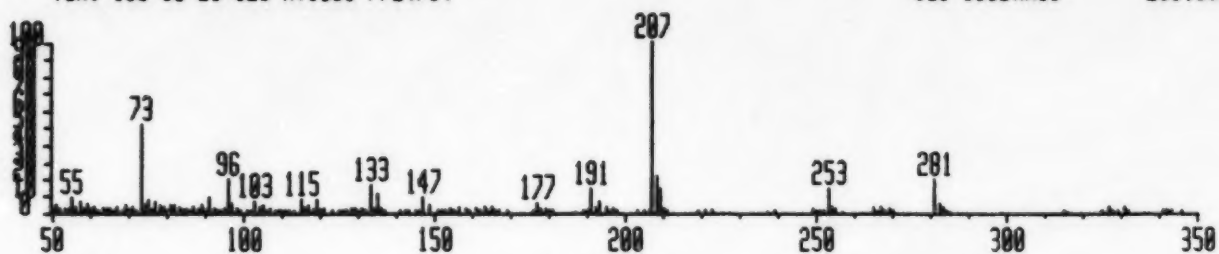
Sys: 350E HMR:

816000

Text: 109 50-20-320 MV1600 7/24/84

Cal: 350E MASS:

206.966



2R109#1163* x1 Bgd=764 24-JUL-84 19:33:0:23:30 12250 EI+

BpM=207 I=131mv Hm=346 TIC=5397000

Acnt: GUELPH

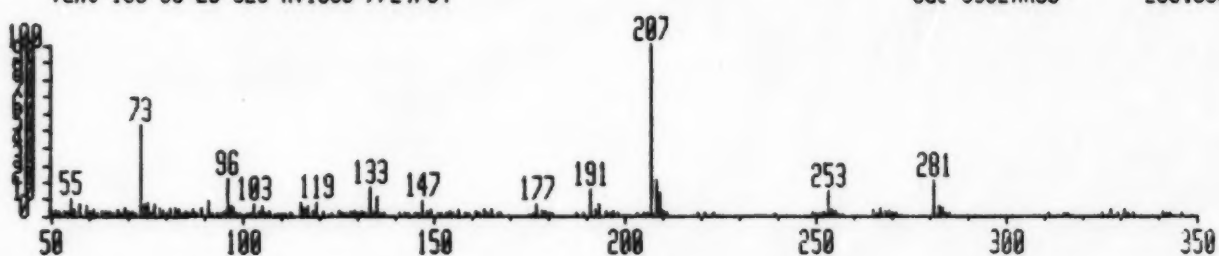
Sys: 350E HMR:

864000

Text: 109 50-20-320 MV1600 7/24/84

Cal: 350E MASS:

206.953



POOR

QUALITY

ORIGINAL